ICP/EXT-03-00967
Revision 0

Estimated Radiological Inventory Sent from the Idaho Nuclear Technology and Engineering Center to the Subsurface Disposal Area from 1952 through 1993

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March 2004

Idaho Completion Project

Bechtel BWXT Idaho, LLC

INEEL/EXT-03-00967
Revision 0
Project No. 23378

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Prepared for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-99ID13727

ABSTRACT

This report provides an improved estimate of the inventory of radiological contaminants shipped from 1952 through 1993 from the Idaho Nuclear Technology and Engineering Center and buried in the Subsurface Disposal Area, part of the Radioactive Waste Management Complex at the Idaho National Engineering and Environmental Laboratory. This inventory has been updated to support development of the comprehensive remedial investigation and feasibility study for Operable Unit 7-13/14 under the Comprehensive Environmental Response, Compensation, and Liability Act.

This report describes in detail the methodology for identifying, collecting, compiling, reviewing, and entering waste inventory information into several inventory reports. Source documents are also described. In addition, descriptions of the following are provided: (1) facilities at the Idaho Nuclear Technology and Engineering Center that generated and shipped waste, (2) specific processes that generated waste, (3) availability of waste disposal information, (4) sources of data, and (5) approaches used to collect data.

ACKNOWLEDGEMENTS

The authors are very appreciative of the many people that have contributed to the radioactive inventory analysis, the writing, the editing, and the review of this report. Without these contributions, this report would not have been possible. First, the authors would like to thank Karen Taylor for her assistance in locating the waste shipment data concerning the INTEC facilities. Second, we would like to thank Craig Kullberg for his initial analysis and the original draft of this report. Many sections of this final report are based on Craig's work. Third, we thank Ed May for his editorial assistance. And finally, the authors would like to thank Nancy Hampton, K. Jean Holdren, Bruce Becker and Brandt Meagher for their management oversight of this program.

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ACRONYMS

ANL-W	Argonne National Laboratory-West
APS	atmospheric protection system
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminants of concern
CPP	Chemical Processing Plant
DD&D	deactivation, decontamination, and decommissioning
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
EBR-II	Experimental Breeder Reactor-II
ETR	Engineering Test Reactor
FDP	fluorinel dissolution process
GPW	general plant waste
HDT	Historical Data Task
HLW	high-level waste
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LLW	low-level waste
MFP	mixed fission products
NRF	Naval Reactors Facility
NWCF	New Waste Calcining Facility
ORIGEN2	Oak Ridge Isotope Generation and Depletion Code Version
OU	operable unit
RI/FS	remedial investigation/feasibility study
RPDT	Recent and Projected Data Task
RWMC	Radioactive Waste Management Complex
RWMIS	Radioactive Waste Management Information System

SDA	Subsurface Disposal Area
SNF	spent nuclear fuel
TRU	transuranic
WAG	Waste Area Group
WCF	Waste Calcining Facility

Estimated Radiological Inventory Sent from the Idaho Nuclear Technology and Engineering Center to the Subsurface Disposal Area from 1952 through 1993

1. INTRODUCTION

This report updates and revises the documented inventory of radiological contaminants generated at the Idaho Nuclear Technology and Engineering Center (INTEC) and disposed of in the Subsurface Disposal Area (SDA), part of the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL). The objective of this update is to include information gathered during extensive additional research since the original estimates were compiled and previously documented in the "Historical Data Task" (HDT; 1952 through 1983), and the "Recent and Projected Data Task" (RPDT; 1984 through 1993) (LMITCO 1995a, 1995b). INTEC began shipping waste to the SDA in 1953.

1.1 Purpose

The objective of compiling these waste inventories is to support development of the comprehensive remedial investigation and feasibility study for the RWMC[a]. Locations of RWMC and the SDA are shown on Figures 1 and 2, respectively. Models that will be used to support the risk analysis of the cleanup are based on historical records of inventories and on investigations such as this report[b]. Waste streams containing Operable Unit (OU) 7-13/14 contaminants of concern (Holdren and Broomfield 2003) and buried in the SDA are being quantified to support investigation required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq. 1980).

1.2 Scope

This report reassesses the disposal histories of INTEC and estimates the radiological contaminants sent from INTEC to RWMC during the two referenced periods (LMITCO 1995a, 1995b). The original HDT and RPDT did not include estimates for the complete nuclide-specific breakdown for contaminants of concern (COCs) identified in the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* report (Holdren et al. 2002). The principal contaminants fall into three categories: activation products, fission products, and actinides (i.e., isotopes of uranium and transuranic elements). The estimates of radiological inventory in this assessment supersede the original HDT and RPDT inventory values. No changes were made to the HDT and RPDT inventory estimates for nonradiological contaminants.

Since waste acceptance criteria and record-keeping protocols for the SDA have changed over time, the receipt of radioactive materials buried in the SDA is divided into two periods reflecting these two different disposal histories: (1) 1952 through 1983 and (2) 1984 through 1993. During the latter period, waste disposal in the SDA was limited to low-level radioactive waste (LLW) from INEEL waste generators; information about handling various types of waste is readily available. Disposal practices are

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a. The RWMC is designated Waste Area Group 7 and the comprehensive remedial investigation/feasibility study (RI/FS) is identified as OU 7-13/14. The RI/FS focuses primarily on the SDA.

b. This study has been developed within the framework of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as implemented in the Federal Facility Agreement and Consent Order (FFA/CO) between the U.S. Department of Energy, the Idaho Department of Environmental Quality, and the U.S. Environmental Protection Agency.

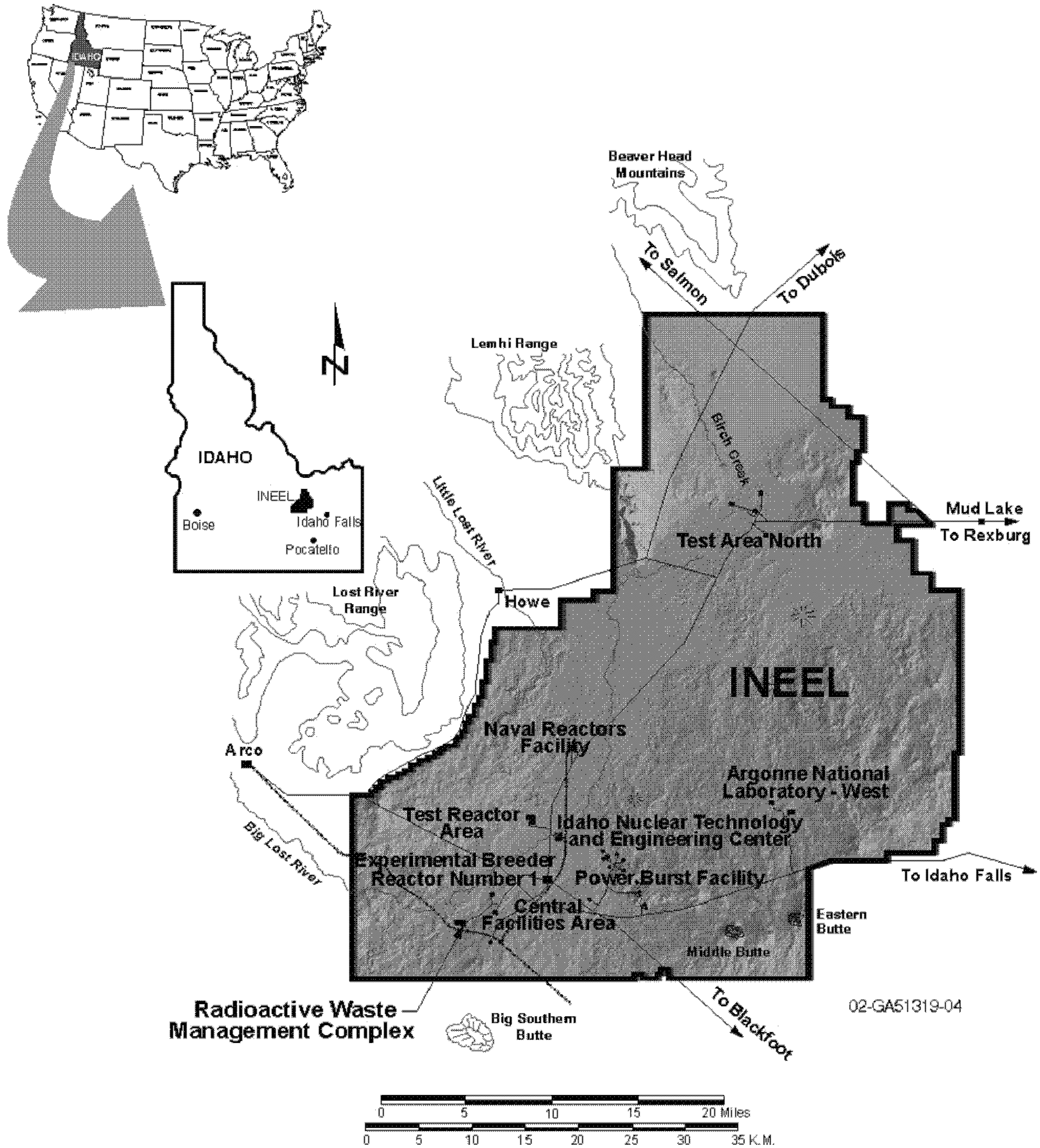

Figure 1. Map of the Idaho National Engineering and Environmental Laboratory showing the location of the Radioactive Waste Management Complex and other major facilities.

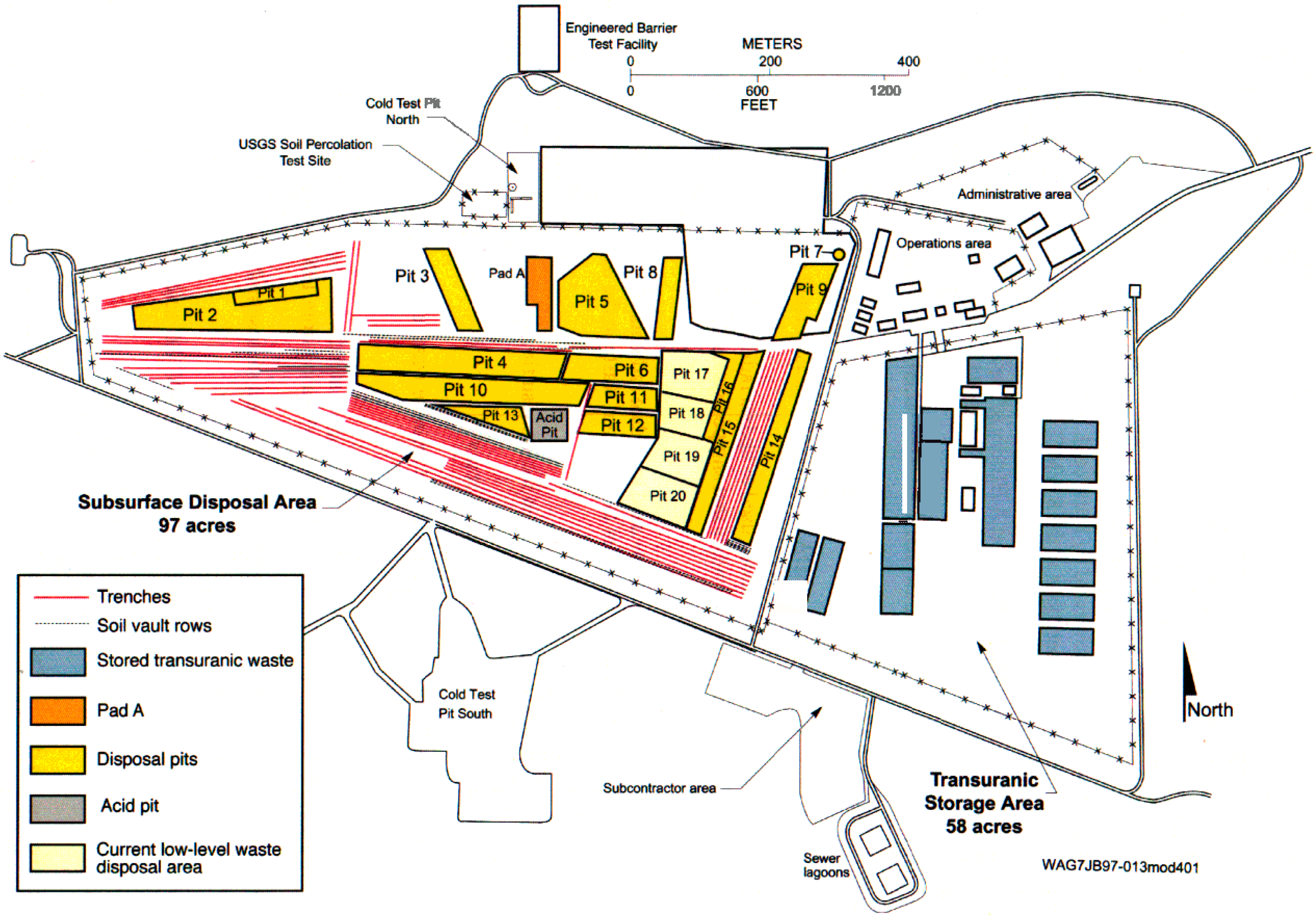

Figure 2. Map of the Radioactive Waste Management Complex showing the location of the Subsurface Disposal Area.

much more stringent today. However, during the earlier period, routine shallow landfill disposal of radioactive and hazardous waste was the commonly accepted technology of choice. Requirements for documentation were predicated on waste-handling issues rather than on long-term environmental impacts. In particular, at the SDA, transuranic and mixed waste—mostly from the Rocky Flats Plant in Colorado—were disposed of through 1970. Low-level mixed waste containing hazardous chemical and radioactive contaminants was normally accepted through 1983. However, these types of wastes are no longer being accepted for routine disposal at the RWMC.

Disposals made after 1993 were reviewed by Little et al. (2001) and are not addressed in this reevaluation. Details of the historical operations at the RWMC, including waste disposal practices, have been previously documented in Section 3 of the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002) and in the report *A History of the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory* (EG&G 1985).

1.3 Document Organization

The following briefly describes the remaining sections in this report:

- Section 2 provides a brief history of the SDA and INTEC and associated generators of waste
- Section 3 documents the results and methods used to update radionuclide waste inventory information for INTEC and affiliated facilities that shipped waste to the SDA for disposal from 1952 through 1983
- Section 4 documents the results and methods used to update radionuclide waste inventory information for INTEC and affiliated facilities that shipped waste to the SDA for disposal from 1984 through 1993
- Section 5 contains the conclusions and recommendations resulting from this effort
- Section 6 lists the references cited throughout this report
- Appendix A documents INTEC fission products and actinide waste disposals during the HDT (LMITCO 1995a) period from 1952 through 1983
- Appendix B contains a yearly Radioactive Waste Management Information System (RWMIS) inventory breakdown during the RPDT (LMITCO 1995b) period from 1984 through 1993
- Appendix C documents the major waste streams of irradiated subassembly hardware sent to the SDA from 1972 through 1983
- Appendix D contains information about the disposals in the INTEC acid pit from 1954 through 1970
- Appendix E discusses the calcine filter data
- Appendix F discusses details of the radioactive source term sent from INTEC to the RWMC.

2. BACKGROUND

This section briefly describes the SDA and INTEC's waste-generating facilities as background for understanding the basis for reassessing the inventory of radiological contaminants generated at INTEC and disposed of in the SDA.

2.1 Brief History and Description of the Subsurface Disposal Area

The SDA is a radioactive waste landfill located within the RWMC at the INEEL in southeastern Idaho (Figure 1). Contaminants in the landfill include hazardous chemicals, remote-handled fission and activation products, and transuranic radionuclides. Located in the southwestern quadrant of the INEEL, the RWMC's 72 ha (177 acres) is divided into three separate areas by function: the SDA, the Transuranic Storage Area (TSA), and the administration and operations area.

The original landfill, established in 1952, was called the NRTS Burial Ground. Now part of the SDA, the original landfill covered 5.2 ha (13 acres) and was used for shallow land disposal of solid radioactive waste. In 1958, the SDA was expanded to 35.6 ha (88 acres). Relocating the security fence in 1988 outside the dike surrounding the SDA established its current size of 39 ha (97 acres). The TSA was added to the RWMC in 1970. Located next to the east side of the SDA, the TSA's 23 ha (58 acres) is used to store, prepare, and ship retrievable transuranic (TRU) waste to the Waste Isolation Pilot Plant (WIPP) southeast of Carlsbad, New Mexico. The 9-ha (22-acre) administration and operations area at the RWMC includes administrative offices, maintenance buildings, equipment storage, and miscellaneous support facilities. For a detailed map of the physical layout of all RWMC disposal locations and facilities, see Figure 2.

2.2 History and Description of Waste Generators at Idaho Nuclear Technology and Engineering Center

Formerly known as the Idaho Chemical Processing Plant, INTEC is 4.8 km (3 miles) north of the Central Facilities Area. The plant is situated on about 85 ha (210 acres) inside the plant's perimeter fence. INTEC was chartered in 1953 to reprocess spent nuclear fuel for recovery and recycling of fissile uranium. Fuel reprocessing at INTEC began in 1953 and continued until April 1992. Most of the fuel that was reprocessed originated from several different facilities in the U.S. Department of Energy (DOE) complex. During those years, about 32 metric tons of highly enriched, reprocessed fuel was produced (Lewis et al. 2000).

INTEC's current mission is to receive and store spent nuclear fuels and radioactive waste, treat and convert waste, and develop new technologies for waste management for DOE. The INTEC facilities once dedicated to reprocessing work are being converted to safe and stable shutdown while waiting for either reuse or deactivation, decontamination, and decommissioning (DD&D).

The seven major facilities at INTEC that sent waste to the SDA are listed below and illustrated in Figure 3:

- Fuel Processing Facility (CPP-601)
- Fluorinel Dissolution Process and Fuel Storage Facility (CPP-666)
- Underwater Fuel Storage Facility (CPP-603)

Legend

CPP-601	Fuel Processing Facility
CPP-666	Fluorinel Dissolution Process and Fuel Storage Facility
CPP-603	Underwater Fuel Storage Facility
CPP-780-786	Tank Farm
CPP-633	Waste Calcining Facility
CPP-659	New Waste Calcining Facility
CPP-602	Miscellaneous laboratories and support facilities
CPP-627	
CPP-630	
CPP-637	

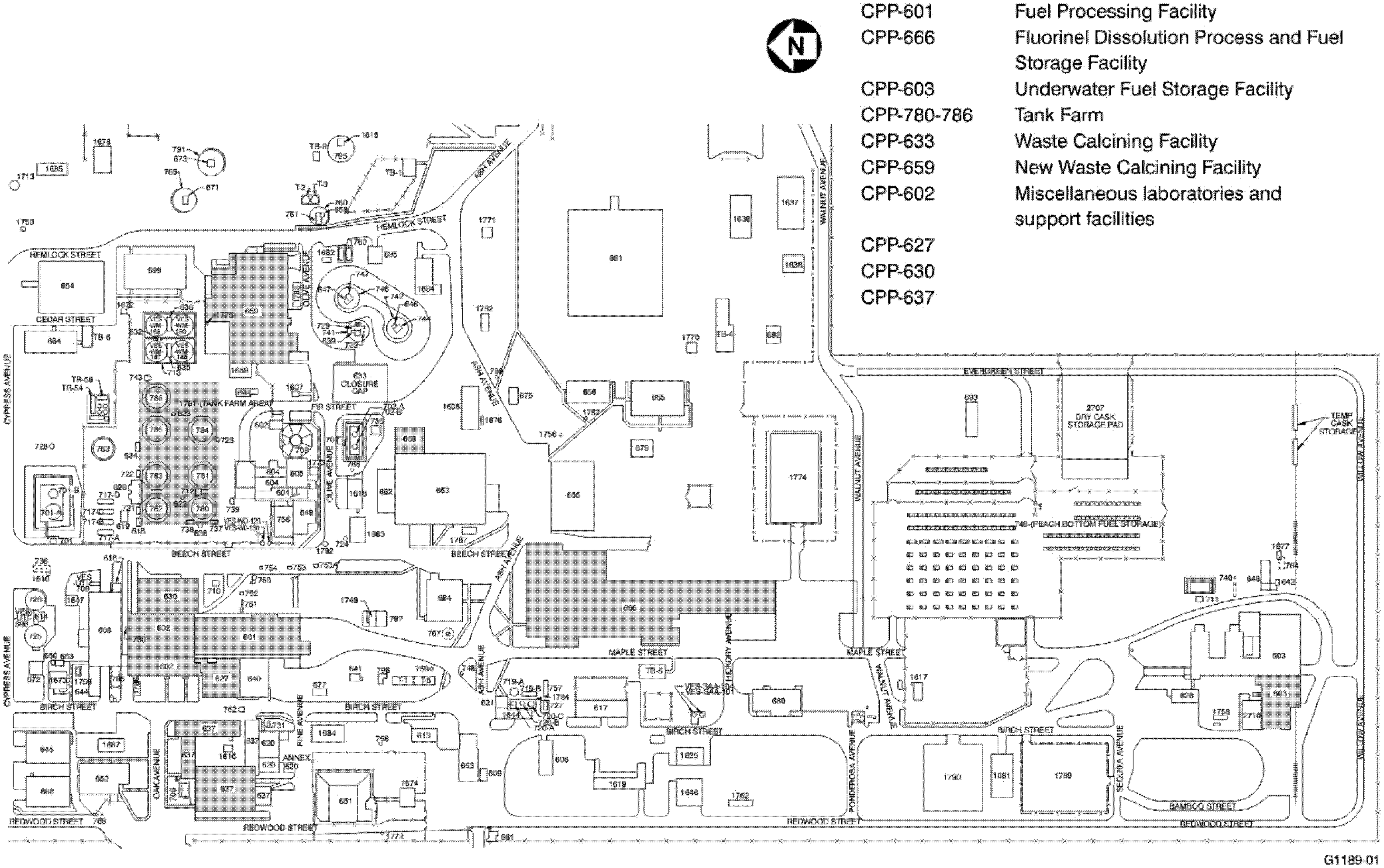

Figure 3. Facilities at INTEC that sent waste to SDA, shaded in gray.

- Tank Farm
- Waste Calcining Facility (WCF; Building CPP-633)
- New Waste Calcining Facility (NWCF; Building CPP-659)
- Miscellaneous laboratories and support facilities (including CPP-602, CPP-627, CPP-630, CPP-637).

2.2.1 Fuel Processing Facility (CPP-601)

The Fuel Processing Facility (CPP-601) began operating around 1953. Its primary function was to reprocess highly enriched spent nuclear fuel. To reprocess the fuel, it was dissolved in both inorganic and organic solvents to recover the uranium. The processing equipment in CPP-601 was inside 29 heavily shielded cells (in fact, nearly 30 % of the building consists of concrete walls for shielding and structural purposes). The bottom of each cell was lined with stainless steel, and most of the equipment was stainless steel, except those structures made of more exotic alloys for resistance to nitric or hydrofluoric acids or electrolytic currents. The inorganic solvents used included nitric and hydrofluoric acids; organic solvents included tributyl phosphate and hexone. Therefore, a substantial fraction of the high-level waste generated by this facility was an acidic liquid, which was then transferred to the Tank Farm before being processed into a stable calcine form (see Section 2.2.4). Acidic liquid decontamination waste (also called "sodium-bearing waste") was generated at the CPP-601 facility and subsequently sent to the Tank Farm for temporary storage.

During its operating history, a number of different fuels were reprocessed in CPP-601, including aluminum alloy-clad fuel, zirconium alloy-clad fuel, and graphite fuel. These fuels originated from several facilities at the INEEL as well as other off-site facilities in the DOE complex. Processed aluminum alloy fuels originated mainly from the INEEL Test Reactor Area. Zirconium alloy fuels originated from the Naval Reactors Facility (NRF). Significant amounts of Vycor glass molds from Argonne National Laboratory (ANL-W) were also reprocessed. Graphite fuel from the Nuclear Rocket Program (ROVER) was reprocessed in custom-designed CPP-601 facilities or interconnected facilities. Additional fuel types reprocessed at CPP-601 are documented by Lewis et al. (2000). CPP-601 is now shut down and waiting for DD&D.

2.2.2 Fluorinel Dissolution Process and Fuel Storage Facility (CPP-666)

In 1986, the fluorinel dissolution process (FDP) began in CPP-666 to reprocess zirconium-clad fuel. The FDP had three large dissolvers that dissolved fuel in a mixture of hydrofluoric acid and aluminum nitrate. The adjoining Fuel Storage Facility consists of six interconnected storage pools containing fully closed racks for zirconium fuel storage. High-level liquid waste streams generated at the FDP are similar to reprocessing waste streams from CPP-601; the waste was shipped to the Tank Farm before conversion into a stable calcine form. Generally, the total activities of other LLW streams from the CPP-666 facility are small in comparison to those from CPP-601 (See Section 3.4).

2.2.3 Underwater Fuel Storage Facility (CPP-603)

The primary spent nuclear fuel (SNF) storage facility (CPP-603) at INTEC was built in 1951. Other interconnected storage basins were added to this facility in 1957 (Meservey 1983). A variety of SNF was stored at CPP-603 until recently. Fuels stored at this facility include aluminum-clad fuels from the Test Reactor Area; zirconium-clad fuels including some from the NRF; sodium-bonded, stainless steel-clad fuel from Experimental Breeder Reactor-II (EBR-II); and a variety of other fuels already mentioned in Section 2.2.2.

In addition to SNF storage operations, some fuel was also cut at this facility. This was a preconditioning step before some fuel reprocessing campaigns. During the operation of this cutting facility, significant amounts of neutron irradiated subassembly hardware were sent from CPP-603 to the SDA (see Section 3.11).

During the operational history of these storage basins, significant amounts of accumulated radioactive sludge on the basin floors were vacuumed, packaged, and sent to the SDA. In addition, filters that purified the water in the basins were also sent to the SDA.

Today, all SNF in CPP-603 has been removed from the facility's underwater storage pools and placed in newer underwater basins (at CPP-666) or in dry storage facilities at the INEEL. The CPP-603 facility is shut down and waiting for DD&D.

2.2.4 Tank Farm

The Tank Farm contains eleven large underground tanks, each having a 300,000-gal capacity and a similar structural design. Liquid high-level waste generated at CPP-601 and CPP-666 during fuel reprocessing was stored at the Tank Farm before being calcined (Palmer et al. 1998). From 1953 to 1999, about eight million gal of this liquid waste from the tanks was processed into a stable calcine form. Sodium-bearing liquid waste from incidental activities was also stored at the Tank Farm. During the operational history of the farm, several leaks developed in transfer lines that either filled or drained liquid waste from the tanks (DOE-ID 2000). Subsequent cleanup work, especially in the 1970s, resulted in disposals of contaminated dirt with significant radiological activities at the SDA. The isotopic profile of this waste stream is estimated in Section 3.10 of this report.

Since the discontinuation of fuel reprocessing in 1992, the Tank Farm has become a temporary storage facility for remaining liquid waste that has not been calcined. Final remediation and cleanup of this facility is in progress.

2.2.5 Waste Calcining Facility (CPP-633)

Between 1963 and 1981, the WCF used fluid-bed calcining to convert aqueous waste from reprocessing nuclear fuel into granular solids (Staiger 1999). The calcining process converted high-level liquid waste from the Tank Farm into a solid form for dry storage in stainless steel bins. The WCF demonstrated that high-level liquid waste could be converted to a noncorrosive and less mobile solid form.

The WCF converted more than (1.5E+07 L) (4 million gal) of high-level liquid waste to less than 1.9E+06 L (500,000 gal) of solid waste between 1963 and 1981. The waste processed in the WCF contained various amounts of hazardous constituents and radiological contaminants. In the course of the many reprocessing campaigns, significant amounts of calcine granules were caught in the calciner filters, which were eventually sent to the SDA. The radiological profiles of this WCF waste are discussed in Section 3.8 of this report. The WCF is now in a DD&D condition.

2.2.6 New Waste Calcining Facility (CPP-659)

The NWCF (Building CPP-659) replaced the WCF with upgraded calcining capability. This production-scale facility converted highly radioactive waste in solution to a solid form requiring only about one-eighth as much space for storage as liquids. NWCF operated from 1982 until 1999. The NWCF converted more than 7.2E+7 L (3.8E+06 gal) of liquid waste to 2.1E+03 cubic meters (7.5E+04 cubic feet) of calcine solids. Records show that no significant amount of waste from this facility was sent to the SDA (see Sections 3.8 and 4.4).

2.2.7 Miscellaneous Laboratories and Support Facilities (including CPP-602, CPP-627, CPP-630, CPP-637)

During INTEC operations, a number of facilities supported its main missions. Analytical laboratories (such as CPP-627) assayed fuels and other materials to ensure that reprocessing was efficient. Other interconnected facilities (such as CPP-602) provided final reprocessing steps (including uranium denitration and packaging for final offsite shipping). Still other facilities provided customized reprocessing of special fuels. An example is the CPP-640 stainless steel dissolver, put in service to reprocess stainless steel fuel from EBR-II. Most of the reprocessed stainless steel fuel originated from ANL-W. In the course of this support, some actinide-bearing waste was sent from INTEC to the SDA. These waste streams are discussed in Sections 3 and 4 of this report.

3. ESTIMATED RADIOLOGICAL INVENTORY FOR 1952 THROUGH 1983

Waste inventory disposals for INTEC were originally compiled for two periods: 1952 through 1983 and 1984 through 1993 (LMITCO 1995a, 1995b). The reassessed disposal inventories for the earlier period are discussed in this section. The later period is discussed in Section 4.

3.1 Background

From 1952 through 1983, INTEC disposal patterns and the isotopic waste profiles show significant variations. These disposal variations are illustrated in Table 1, showing yearly reported inventory disposals of net radionuclide activities. Several major disposal trends shown in Table 1 correlate directly with major waste production trends at INTEC. Additional details of major trends in disposal of waste streams during the HDT period are presented in Appendix A. A more formal and systematic way of categorizing these key waste streams is presented in Section 3.2. A historical summary of INTEC waste disposals recorded in the HDT is in the following paragraphs.

The most prevalent type of waste sent to the SDA during the entire HDT period consisted of routine or general LLW that was in a solid form. Shipments of general plant LLW from INTEC included byproducts from decontamination operations, equipment replacement, and other operational activities that did not have high activities associated with individual disposals. Major trends shown in Table 1 were dominated by other kinds of waste streams that contained enhanced amounts of fission products, actinides, or activation products. In other cases, the physical form of the waste stream also influenced how waste streams other than general plant waste (GPW) were defined. A chronology of other waste forms is discussed below.

In the first decade of the HDT period, limited documentation is available for material sent from INTEC to the SDA. The first available documentation is from disposal of liquid waste beginning in 1954 with disposals to the acid pits. After 1960, shipments to the acid pits declined sharply but continued sporadically until 1970. The radionuclide activities were usually not explicitly reported in these shipments; however, explicit weights of dissolved alpha-emitting actinides (such as uranium) generally were reported. Consequently, some of the activity entries for this decade are left blank or incomplete in Table 1. Shipping records for solid waste disposals begin in 1959 and thus Table 1 shows an abrupt increase in reported radioactivities. However, since the solid waste disposals began before1959, the entries in Table 1 are incomplete. The reassessed profiles of isotopic activity for disposals in the acid pit are discussed in Section 3.4. Note that the data reflect the activities of the waste at the time of burial, and not as decayed to a future date.

During the 1960s, disposals to the SDA were initially characterized by routine shipments of mainly low-activity GPW. However, other disposals consisted of solidified fuel samples that had been originally dissolved for analysis, and bulk disposal of unirradiated surplus fuel mockups. These surplus mockups were used in “cold” testing of fuel materials that were dissolved in reprocessing tests. During the early 1960s, disposals to the SDA remained relatively steady; and net yearly activities remained relatively low. These kinds of disposals continued throughout the HDT period and are reassessed in Sections 3.5, 3.6, and 3.7.

Table 1. Summary of net activity for annual disposals in the SDA reported from 1954 through 1983.

SDA Disposal Year	Gross Annual Activity (Ci)	Actions and Comments
1954	—	First known shipments of waste to the SDA acid pit
1955	—	—
1956	1.3E+00	—
1957	—	—
1958	—	—
1959	2.8E+02	—
1960	8.4E+01	—
1961	2.1E+02	—
1962	2.0E+02	Explicit shipments of dissolved stabilized fuel sent to the SDA
1963	3.6E+02	—
1964	2.3E+02	Disposal begins of WCF filters to the SDA
1965	1.7E+02	—
1966	1.9E+04	Disposal begins of reprocessed of EBR-II Vycor glass
1967	1.5E+04	—
1968	1.1E+04	—
1969	4.2E+04	Disposal of one time NRF experimental waste
1970	1.4E+02	End of Vycor glass and acid pit disposals
1971	1.1E+02	—
1972	1.6E+02	—
1973	3.3E+05	First disposals of EBR-II subassembly hardware from INTEC
1974	5.7E+03	Major shipments begin of Tank Farm contaminated soil
1975	9.5E+03	Major shipments end of Tank Farm contaminated soil
1976	1.1E+03	—
1977	6.4E+03	Major disposals begin of basin sludge from fuel storage at CPP-603
1978	1.1E+04	—
1979	4.4E+03	—
1980	1.9E+04	End of disposals of basin sludge from CPP-603
1981	1.7E+04	—
1982	1.1E+05	Last disposal to SDA of EBR-II subassembly and WCF filters
1983	3.0E+02	—

CPP = Chemical Processing Plant
EBR-II = Experimental Breeder Reactor-II
NRF = Naval Reactors Facility
SDA = Subsurface Disposal Area
WCF=Waste Calcining Facility

In 1966, there was a significant increase in net activity disposals to the SDA. These activity increases were related to programs connected with both ANL-W and NRF. The ANL-W contribution came from the pyrometallurgical reprocessing campaign operated from 1964 through 1969 using waste from EBR-II (Stevenson 1987). This INTEC-processed pyrometallurgical waste stream of leached Vycor glass contained mainly fission and actinide products. Contaminant activity profiles for the Vycor glass waste are reassessed in Section 3.6 of this report. Additionally, an NRF-supported experiment conducted at INTEC produced a significant single waste stream that was sent to the SDA in 1969. This waste stream also consisted of mainly fission product and actinide contaminants. Contaminant activity profiles connected with this NRF-related waste stream are reassessed in Section 3.7 of this report.

From 1964 until 1982, WCF filters were buried at the SDA (Wenzel 2000b). In addition, there were shipments of lower-activity filters from a variety of facilities having off-gas filter systems—including vessel off-gas and dissolver off-gas filters from reprocessing systems at INTEC—which contained radionuclides with distributions similar to the calcine filters. Contaminants from the WCF filters in addition to other miscellaneous filters sent to the SDA were significant. The principal contaminants in this waste stream consisted of calcine product fission products and TRU nuclides. The activity profiles for this waste stream are reassessed in Section 3.8 of this report.

In the 1970s, several new kinds of waste were sent to the SDA. These shipments included irradiated subassembly hardware, sludge from the CPP-603 basins (specially shielded and packaged), and raffinate-contaminated topsoil (See Sections 3.9, 3.10, and 3.11 of this report). Waste subassembly hardware was generated from fuel reprocessing operations at INTEC. The first known hardware disposals began in 1973; main contaminants consisted of neutron activation products (Carboneau 1998). Basin sludge disposals were corroded fuel particles—accumulated over a number of years on the bottom of the fuel storage basins in CPP-603—sent to the SDA in large shielded casks from 1977 to 1980. The primary contaminants were fission products and actinides. Contaminated soil from areas next to the Tank Farm resulted from leaks in the liquid transfer lines. Raffinates[c] (that is, acidic radioactive liquids) contaminated soil around some of these leaking transfer lines. During cleanup and repair, some of this soil from the Tank Farm was sent to the SDA. This waste stream contained significant amounts of fission products and some actinide contaminants.

Disposals into the 1980s were characterized by final shipments of irradiated hardware and basin sludge along with some other solid actinide-bearing shipments. However, by 1983 disposals of contaminants in the SDA had suffered a sharp decline. This abrupt reduction in contaminant disposals that continued into the RPDT period is discussed in Section 4.2. Net inventory activities from 1960 through 1970 are based on Form 110 shipping manifests.

3.2 Disposal Waste Streams

The original HDT waste streams (LMITCO 1995a) and modified waste stream definitions for 1952 through 1983 are in Table 2. Although the waste streams originally identified for this period were complete, the distinction between high-activity and low-activity waste streams was not always clear in some of those original definitions. In redefining those waste streams, solid, low-activity GPW streams were separated from other higher activity waste streams consisting of fission products or activation products. These low-activity waste streams had only traces of fission, actinide, and activation products. Where possible, higher activity waste streams were combined with others having similar contaminant profiles. In a number of other cases, waste streams were renamed for purely administrative reasons (for example, the original CPP prefix has been superceded with INTEC).

c. "Raffinate" is a generic name for waste dissolved in organic or inorganic solvents used in fuel processing.

Table 2. Original and current descriptions for INTEC waste streams buried in the SDA from 1952 through 1983.

Original Waste Stream Descriptions[a]		Current Waste Stream Descriptions	
Waste Stream Number	Description of Waste	Current Waste Stream Number	Description of Waste
CPP-601-4H	Acidic aqueous liquid	INTEC-MOD-1H	Liquid acid pit disposals consisting of acidic, organic, and other aqueous liquid waste streams
CPP-601-5H	Organic solvents	INTEC-MOD-1H	Organic solvents
CPP-603-4H	Decontamination chemicals	INTEC-MOD-1H	Decontamination chemicals
CPP-601-1H	Leached Vycor glass	INTEC-MOD-2H	Leached Vycor glass
CPP-601-3H	Dissolved fuel specimens	INTEC-MOD-3H	Fuel-bearing waste such as unirradiated and irradiated fuel specimens. Solid actinide waste primarily consisting of natural and depleted fuel mockups.
CPP-601-7H	Zirconium and zirconium-uranium alloy	INTEC-MOD-3H INTEC-MOD-4H	 One-time-only Navy experiment.
CPP-633-1H	High-efficiency particulate air filters	INTEC-MOD-5H	HEPA filter from WCF and other filters from miscellaneous facilities.
CPP-603-3H	Fuel storage sludge	INTEC-MOD-6H	CPP-603 basin sludge
CPP-603-5H	Zeolite	INTEC-MOD-6H	Miscellaneous storage basin Zeolite filters
CPP-604-1H	Surface soil	INTEC-MOD-7H	Contaminated soil from Tank Farm spills
CPP-603-1H	Fuel end pieces	INTEC-MOD-8H	Irradiated subassembly hardware 1973 through 1982 for which principal contaminants were activation products.
CPP-601-6H	Pipe, glass, gloves, cans, vessels wire, valves, paper, metal, wood, clothing, filters, plastic bottles, and rubber	INTEC-MOD-9H	General plant waste 1952 through 1983. Consisting of metal, glass, paper, metal, wood, clothing, plastic, dirt, and shielding material.
CPP-603-6H	Contaminated roof materials and top soil	INTEC-MOD-9H	—

CPP = Chemical Processing Plant
HEPA = high-efficiency particulate air
INTEC = Idaho Nuclear Technology and Engineering Center
WCF = Waste Calcine Facility
a. Original waste streams defined as part of the Historical Data Task (LMITCO 1995a).

All liquid wastes that were sent to the SDA acid pit (formerly CPP-601-4H and CPP-601-5H) and any liquid decontamination chemicals (CPP-603-4H) were combined and designated as INTEC-MOD-1H. These waste streams contained primarily unirradiated uranium isotopic contaminants with some trace amounts of fission products.

All solid actinide (mainly unirradiated uranium fuel mockups) and stabilized dissolved fuel samples were recombined and defined as waste stream INTEC-MOD-3H. Fuel samples (with one exception) were chemically dissolved and stabilized in inert materials such as vermiculite before burial in the SDA. Formerly these streams were CPP-601-3H and CPP-601-7H (see Table 2). The one-time-only waste stream dealing with a Navy-sponsored test was separately identified as INTEC-MOD-4H because of the high fission content of this stream and its unique isotopic contaminant profile.

The designation for surface soil was changed from CPP-604-1H to INTEC-MOD-7H. Also the definition of this waste stream was changed. The new stream INTEC-MOD-7H refers to high-activity disposals associated with significant ground leakage events of liquid high-level waste. Other low-activity disposals of dirt generated from routine operations are classified as GPW.

Contaminated sludge from storage basins in CPP-603 and miscellaneous disposals of water filters from the storage basins were designated as waste stream INTEC-MOD-6H. Before, the basin sludge and zeolite filter waste streams were separately designated CPP-603-3H and CPP-603-5H.

Some waste streams were renamed without redefining the contents. The Vycor glass waste stream was changed from CPP-601-1H to INTEC-MOD-2H. Vycor glass was a high-activity waste stream containing fission products and TRU contaminants. The designation of irradiated fuel end pieces was changed from CPP-603-3H to INTEC-MOD-6H.

All of the low-activity shipments of GPW were reclassified and combined into waste stream INTEC-MOD-9H. This stream includes low-level waste shipments from waste streams CPP-601-6H and CPP-603-6H. This waste stream included byproducts from routine operations that generated a number of miscellaneous byproducts, such as cloth, wood, and paper. Individual shipments in this waste stream contain only traces of fission products, activation products, and actinides.

3.3 Data Collection and Analysis

The general data-collection approach was to review any available documentation that was pertinent to SDA disposal operations during the HDT period. This documentation fell into two categories. The first category included actual shipping manifests or electronic databases that contained SDA disposal information. The second category included documents containing process information connected with actual disposals.[d] Collection methods of waste disposal information depended on availability and three general time frames: (1) 1952 through 1959, (2) 1960 through 1970, and (3) 1971 through 1983.

During the first period (1952 through 1959), information on shipping and disposal was the most limited. Forms IHP for shipments of liquid waste to the SDA acid pits were available from 1954 to 1959. However, forms for disposing of solid waste were generally not available for this same period.

For the second period (1960 through 1970), documentation was based on hard copies of standardized U.S. Atomic Energy Form 110, "Idaho Operations Office Waste Disposal Request and

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d. Relevant process-related documents are listed in the references section of this report (Section 6).

Authorization," (AEC 1964), solid waste disposal forms.[e] These forms generally reported waste types sent to the SDA, including net activities per shipment, for 1960 through 1970.

For the third period (1971 through 1983), the INEEL database (Radioactive Waste Management Information System [RWMIS]) proved to be a more detailed source of information for estimating a complete nuclide-specific breakdown of contaminants of concern (COCs). Also, Form 110 disposal manifests for this period reported more detailed isotopic breakdowns of individual shipments. For consistency, hard copies of selected Form 110s were crosschecked with RWMIS entries.

The RWMIS data was entered into Excel spreadsheets, organized by year from 1971 through 1983. Each waste shipment has a separate data entry including date and location of the disposal, the general contents (using a numerical waste stream identification code), and shipping container (using a numerical container identification code). Accompanying these entries were estimates of the net activities. Generally, these net activities were in turn accompanied by other more isotope-specific activities. However, the fission products reported for each shipment were generally limited to activities for such contaminants as Cs-137 and Sr-90 and did not report other contaminants of interest such as Tc-99 and I-129. See Appendix A for a summary of net RWMIS contaminant activities for 1971 through 1983 and their scaling factors.

Methods to reassess SDA contaminant inventories for major identified waste streams are discussed in the following sections.

3.4 Acid Pit Disposals

This section summarizes best-estimate activities of liquid bearing waste streams sent to the SDA from 1954 through 1970. This waste stream was identified as item INTEC-MOD-1H in Table 2. Although most shipments in these waste streams were low activity (because of the presence of mainly alpha emitter actinides), these shipments were differentiated from other low-activity GPW streams for two reasons. First, this waste stream consisted of liquid-bearing, fuel-reprocessing byproducts. All other waste streams associated with INTEC operations were in solid form.[f] Secondly, this waste stream was buried in a specially designated Acid Pit zone of the SDA (see Figure 2). The principal radiological contaminants in the Acid Pit disposals were uranium nuclides. In some cases, these disposals contained reported traces of fission products. However, actual activity content was seldom reported.

Available shipping information indicates that disposals to the Acid Pit began in 1954 and ended in 1970. However, after 1959 only a handful of shipments are known to have been sent to the Acid Pit. Available shipping records of waste shipments from INTEC to the Acid Pits were identified as copies of Chemical Waste Disposal Request and Authorization Forms (IHP 36 forms).[g] Those records were compiled into a spreadsheet listing all radioactive materials disposed of in the RWMC Acid Pit (see Appendix D). That listing was then independently audited against the record copies. Those entries were also compared with entries in Table 1-1 of Jorgensen et al. (1994). There was generally excellent agreement between the data sets.

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e. A few IHP manifests for disposals after 1959 were also available.

f. Some dissolved fuel samples were buried in SDA trench locations. However, this liquid material was first mixed with solid stabilizers such as vermiculite before burial.

g. Data in the IHP 36 forms will be entered into WasteOScope.

The uranium contaminants of interest sent to the Acid Pit included U-234, U-235, and U-238. U-236 was not a suspected contaminant since the raffinates were waste byproducts of "cold line" tests of fuel reprocessing. These cold line tests used fuel mockups consisting of alloyed fuel made mostly of natural or depleted uranium; the raffinates included dissolved uranium in nitric, hydrofluoric and sulfuric acids, and organic uranium-bearing solvents such as tributyl phosphate and hexone. Since this fuel was unirradiated, U-236 capture products were not present.[h]

Best estimates of the total uranium-bearing raffinates are shown in Table 3. Details of the isotopic analysis used to calculate these activities are in Appendix A, including net yearly activity disposals. The associated spreadsheet listings of individual shipments are in Appendix D. A total of 293 kg of dissolved uranium was reported as buried in the acid pits. Of this total, 0.5 kg was enriched uranium (1950s disposals), 82 kg was natural uranium, and 211 kg was depleted uranium. These differing amounts of uranium were the explicit base line quantities used to calculate best estimate activity of disposals to the Acid Pit. Presented in Appendix A are lower-bound, best-estimate, and upper-bound activities sent to the SDA on a yearly basis. Upper-bound estimates were approximated as 1.5 times the best estimate.

Table 3. Total best-estimate activity for Acid Pit disposals from 1952 through 1983.

Year	U-234 (Ci)	U-235 (Ci)	U-238 (Ci)
1954	1.90E-02	6.70E-04	2.70E-02
1955	3.40E-02	1.20E-03	6.30E-02
1956	9.50E-03	3.30E-04	6.90E-03
1957	1.70E-03	6.00E-05	1.30E-03
1958	1.50E-03	5.10E-05	7.10E-04
1959	1.60E-04	5.60E-06	1.20E-04
1960	0.00E+00	0.00E+00	0.00E+00
1961	0.00E+00	0.00E+00	0.00E+00
1962	3.50E-04	1.20E-05	2.60E-04
1963	0.00E+00	0.00E+00	0.00E+00
1964	2.50E-05	8.80E-07	1.10E-08
1965	0.00E+00	0.00E+00	0.00E+00
1966	2.30E-04	8.00E-06	9.60E-08
Total	6.60E-02	2.30E-03	9.90E-02

3.5 Solid Actinide Disposals

This section summarizes the best-estimate analysis for the activity in disposals of dry-solid actinide-bearing waste streams sent to the SDA between 1963 and 1983. This waste stream is identified as INTEC-MOD-3H in Table 2. Details of the best-estimate analysis of this waste stream are in Appendix A of this report. Although most shipments of these wastes were low-activity, these shipments are distinguished from GPW streams mainly because of the presence of alpha emitter actinides. The GPW streams were also low-activity shipments. In contrast, the GPW shipments contained none or only trace amounts (much less than a gram) of actinide contaminants.

h. It was also unlikely that any of the enriched uranium contained U-236 from reprocessed irradiated uranium since the reprocessing cycle was not mature enough in the 1950s to allow reprocessed material to be recycled.

Materials in waste stream INTEC-MOD-3H are further divided into two subcategories. The first category involved intermittent bulk disposals containing either unirradiated thorium and uranium actinides. Most of the uranium bearing shipments contained either depleted or natural uranium material that was alloyed with other metals, like zirconium. Explicit shipments of thorium materials were identified as consisting of thorium carbide. In some cases, these kinds of wastes were surplus fuel mockups that had been used as "cold" test material for fuel reprocessing trials. The cold test runs were conducted at the INTEC main reprocessing facilities. Bulk disposals of actinide weights varied from several kilograms to several hundred kilograms of material per shipment.

The second, smaller category of explicitly reported solid actinide waste streams included unirradiated enriched fuel that was initially dissolved and then stabilized in vermiculite or other solid stabilizing media. These kinds of disposals were byproducts of chemical analyses conducted at INTEC analytical laboratory facilities. In some cases during the 1960s, irradiated enriched fissile material or fissile material co-located with fission product waste were sent to the SDA. Therefore, trace amounts of TRU contaminants were reported in some disposals. However, these types of sporadic disposals were discontinued after 1970. Such enriched fuel-based disposals contained actinide weights ranging from several grams to hundreds of grams of actinide.

A total of 790 kg of actinide was explicitly reported as sent to the SDA from INTEC for the waste stream INTEC-MOD-3H. Net disposals of actinide contaminants for this waste stream included 460 kg of natural uranium, 230 kg of depleted uranium, 4.4 kg of enriched uranium, and 100 kg of thorium. The amount of reported TRU contaminants in these shipments amounted to a total of 3 g of Pu-239. More detailed yearly breakdowns of these actinide disposals to the SDA are in Appendix A. The total HDT best-estimate activities for these actinide contaminant activities are in Table 4.

Most of the previously mentioned actinide disposals originated from operations conducted directly at INTEC. However, some of this material originated from off-site sources and involved materials transshipped to INTEC before burial at the SDA. Examples of such shipments include zirconium-uranium scrap sent from Atomics International to INTEC. It is not clear that all of the documentation for such transshipped waste has been located. Therefore, the baseline reported amounts of contaminants have attendant uncertainties that must be taken into account. There are also other inherent uncertainties connected with reporting disposals from available shipping manifests. Consequently, upper and lower bounding estimates of actinide contaminants have been adjusted to account for these uncertainties in the best-estimate amounts of contaminants for this wastes stream. The total HDT best-estimate activities for these actinide contaminant activities are in Table 4. Additional details of this best-estimate analysis with waste stream upper and lower bounding estimates are in Appendix A.

3.6 Vycor Glass Disposals

This section summarizes best-estimate activity disposals of leached Vycor glass waste streams sent to the SDA from 1966 through 1970. This waste stream is identified as item INTEC-MOD-2H in Table 2. Review of this information would logically rely on shipping information and an external reference that chronicled reprocessing activity connected with this waste stream (Stevenson 1987).

Table 4. Total best-estimate activity for solid actinide disposal waste streams from 1952 through 1983.

Year	U-234 (Ci)	U-235 (Ci)	U-238 (Ci)	Pu-239 (Ci)	Th-232 (Ci)
1952–1961[a]					
1962	7.0E-03	2.4E-04	6.5E-04	—	—
1963	7.0E-02	2.4E-03	0.0E+00	—	—
1964	2.7E-05	9.4E-07	0.0E+00	—	—
1965	—	—	—	—	—
1966	3.2E-03	1.1E-04	5.7E-05	—	—
1967	6.2E-02	2.8E-03	6.3E-02	—	—
1968	4.6E-02	2.0E-03	3.9E-02	—	—
1969	2.6E-04	8.8E-06	1.5E-06	—	—
1970	9.7E-02	4.2E-03	9.9E-02	—	—
1971	1.2E-02	4.1E-04	1.4E-03	1.8E-01	—
1972	8.5E-02	2.9E-03	1.0E-04	—	1.097E-07
1973	1.5E-02	6.5E-04	2.2E-02	—	—
1974	4.2E-03	1.4E-04	1.9E-03	—	—
1975	2.7E-02	9.2E-04	7.5E-05	—	1.1E-02
1976	4.3E-04	1.5E-05	1.1E-05	—	—
1977	—	—	—	—	—
1978	—	—	—	—	—
1979	—	—	—	—	—
1980	—	—	—	—	1.155E-05
1981	—	—	—	—	—
1982	6.8E-05	3.1E-06	1.1E-03	—	—
1983	—	—	1.5E-05	1.2E-03	—

a. No disposals of solid actinide waste was reported from 1952 to 1961.

In 1964, an experimental program began to demonstrate the feasibility of pyrometallurgical reprocessing of EBR-II fuel.[i] This activity was conducted at ANL-W. A remotely operated production line was used to reprocess spent EBR-II fuel and return it to the reactor. Part of the production process involved fabricating new fuel pins. The pins were made from reconditioned irradiated fuel that was melted and poured into Vycor glass molds. When the new fuel pins had solidified, the glass molds were crushed and the new pins removed. About four tons of new fuel pins were made using this process.[j] Some fuel and a considerable amount of fission products were embedded in the broken Vycor glass molds. The scrap glass was sent to INTEC to recover the remaining enriched uranium.

Shipping records indicate that leached Vycor glass disposals to the SDA began in 1966 and ended in 1970. A total 4.6E+04 Ci of fission product activity was associated with all of these leached Vycor disposals.[k] Along with substantial amounts of fission products was an estimated 8-16 kg of actinide residues that remained on the Vycor glass after the leaching process was completed.

Table 5 shows the best-estimate contaminant activities for Vycor glass disposals. Contaminant profiles relied on ORIGEN2 (Croft 1980) analysis of EBR-II Mark-I fuels (Wenzel 2000a). One of the principal uncertainties connected with the analysis is quantifying variations in fuel burnups (burnups varied from 1–6% of the initial U-235). Another uncertainty results from fission product depositions onto the Vycor molds being highly variable because they were not directly measured. These uncertainties were factored into the calculated best-estimate activities in Table 5. More details of this best-estimate analysis along with waste stream upper and lower bounding estimates are in Appendix A.

3.7 Navy Disposals

This section details the reassessment of reported activities from waste produced by a one-time-only experiment in 1969. This Navy-sponsored test processed irradiated test specimens from Engineering Test Reactor (ETR) in a specially designed hot cell (LMITCO 1995a). This waste stream is identified as INTEC-MOD-4H in Table 2. Unlike other irradiated actinide-bearing waste from the 1960s, this Navy-related disposal contained an exceptionally large amount of activity. Generally, gross activity disposals for the 1960s reported only net gamma activities in shipments. Of the approximately 4.2E+04 Ci sent to the SDA in 1969, 4.0E+04 Ci were attributed to this one waste stream (see Table A-1). The principal contaminants in this waste stream included fission products and some actinides and traces of activation products. Review of this waste stream relied on available Form 110 shipping manifests and supporting references. Known shipping data were crosschecked with other external documents for consistency in reporting the net 1969 activity for solid waste disposals to the SDA. The cross checks indicated that net activities from available shipping records were consistent with previously reported INTEC net activity for SDA disposals in 1969 (Plansky and Hoilan 1992; Osloond 1970).[l]

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i. After 1969, that mission was discontinued following successful demonstration of the pyrometallurgical reprocessing technology.

j. About 80% of the casting was from irradiated fuel and 20% from unirradiated uranium feed stocks.

k. However, some of the reported contaminated glass disposals may not have been associated with the ANL-W reprocessing campaign (LMITCO 1995a).

l. These references identified only net amounts of activity sent to the SDA in 1969; details of the Navy-sponsored experiments were not included.

Table 5. Total best-estimate activity contaminants for the Vycor glass waste streams from 1952 through 1983.[a]

Nuclide	1966 (Ci)	1967 (Ci)	1968 (Ci)	1969 (Ci)	1970 (Ci)
H-3	1.4E+02	1.1E+02	7.8E+01	1.3E+01	3.7E-01
Be- 10	5.8E-07	4.5E-07	3.3E-07	5.5E-08	1.5E-09
C-14	2.3E-05	1.8E-05	1.3E-05	2.2E-06	6.2E-08
Sr-90	1.7E+04	1.4E+04	9.9E+03	1.7E+03	4.6E+01
Nb-94	3.4E-06	2.7E-06	2.0E-06	3.3E-07	9.2E-09
Tc-99	2.7E+00	2.1E+00	1.6E+00	2.6E-01	7.3E-03
I-129	7.3E-03	5.8E-03	4.2E-03	7.1E-04	2.0E-05
Cs-137	1.9E+04	1.5E+04	1.1E+04	1.8E+03	5.0E+01
Eu-152	1.0E-01	7.9E-02	5.7E-02	9.6E-03	2.7E-04
Eu-154	1.6E+01	1.3E+01	9.3E+00	1.6E+00	4.4E-02
Pb-210	1.3E-10	1.0E-10	7.5E-11	1.3E-11	3.5E-13
Ra-226	3.3E-09	2.6E-09	1.9E-09	3.1E-10	8.8E-12
Ra-228	2.1E-14	1.7E-14	1.2E-14	2.0E-15	5.7E-17
Ac-227	1.9E-08	1.5E-08	1.1E-08	1.8E-09	5.0E-11
Th-228	1.4E-05	1.1E-05	8.3E-06	1.4E-06	3.9E-08
Th-229	4.0E-10	3.2E-10	2.3E-10	3.9E-11	1.1E-12
Th-230	3.8E-06	3.0E-06	2.2E-06	3.7E-07	1.0E-08
Th-232	1.3E-13	1.0E-13	7.3E-14	1.2E-14	3.4E-16
PA231	3.1E-07	2.4E-07	1.8E-07	3.0E-08	8.3E-10
U-232	2.0E-05	1.6E-05	1.2E-05	2.0E-06	5.5E-08
U-233	7.7E-07	6.0E-07	4.4E-07	7.4E-08	2.1E-09
U-234	1.1E-01	8.5E-02	6.2E-02	1.0E-02	2.9E-04
U-235	3.7E-03	2.9E-03	2.1E-03	3.5E-04	9.9E-06
U-236	7.2E-04	5.6E-04	4.1E-04	6.9E-05	1.9E-06
U-238	5.2E-04	4.1E-04	3.0E-04	5.0E-05	1.4E-06
Np-237	5.4E-05	4.2E-05	3.1E-05	5.2E-06	1.5E-07
Pu-238	7.1E-03	5.6E-03	4.1E-03	6.8E-04	1.9E-05
Pu-239	2.9E-01	2.3E-01	1.7E-01	2.8E-02	7.8E-04
Pu-240	2.2E-03	1.7E-03	1.2E-03	2.1E-04	5.8E-06
Pu-241	1.3E-03	1.0E-03	7.4E-04	1.2E-04	3.5E-06

Table 5. (continued).

Nuclide	1966 (Ci)	1967 (Ci)	1968 (Ci)	1969 (Ci)	1970 (Ci)
Pu-242	5.4E-11	4.3E-11	3.1E-11	5.2E-12	1.5E-13
Pu-244	6.3E-22	5.0E-22	3.6E-22	6.1E-23	1.7E-24
Am-241	7.2E-06	5.7E-06	4.1E-06	6.9E-07	1.9E-08
Am-243	2.2E-12	1.8E-12	1.3E-12	2.1E-13	6.0E-15
Cm-243	5.3E-12	4.1E-12	3.0E-12	5.1E-13	1.4E-14
Cm-244	1.1E-12	9.0E-13	6.5E-13	1.1E-13	3.1E-15
Cm-245	2.8E-18	2.2E-18	1.6E-18	2.7E-19	7.4E-21
Cm-246	1.6E-21	1.3E-21	9.4E-22	1.6E-22	4.4E-24
Total	3.6E+04	2.8E+04	2.1E+04	3.5E+03	9.7E+01

a. No disposals of Vycor glass waste was reported from 1952 to 1965

Information about the actual hot cell experiment was limited (LMITCO 1995a). A test specimen, or specimens, reported to contain approximately 5 g of U-235 was irradiated in the ETR. Then this irradiated material was sent to INTEC to be tested in an experimental dissolution process for recovering enriched uranium. After the test, the highly radioactive raffinates generated were stabilized in plaster of Paris. This solidified material was put in polyethylene containers and sent to the SDA for burial. The reported gross activity for this shipment was 4.0E+04 Ci. It is unlikely that the gross activity was directly measured since the disposal manifest noted that this gross activity had been estimated.

The HDT report (LMITCO 1995a) states that of the 4.0E+04 Ci sent to the SDA, 4.0E3 Ci consisted of Cs-137 contaminants. However, such a large Cs-137 activity corresponds to an artificially large amount of U-235 for an equivalent amount of irradiated fuel. This observation suggests that the amount of disposed U-235 was either grossly under-reported or the reported gross activity was wrong. Further examination of classified INTEC reports of this Navy experiment showed that the reported amount of disposed U-235 was correct. Secondly, the net reported activity most likely included predominantly short half-lived beta activities from contaminants like Zr-95. In general, irradiated actinide-bearing waste has much lower beta activities before burial since this material has several years to cool down before shipment to the SDA. However, in the case of the ETR experiment, the test specimens were fresh and had little or no time to decay out short half-lived nuclides.

The reassessed best-estimate activity of the amount of Cs-137 in the Navy-sponsored experiment is 7 Ci, compared to the original HDT estimate of 4.0E3 Ci. This revised activity is based on Wenzel's generic fuel analysis (Wenzel 2000a) showing that freshly irradiated pressurized water reactor fuel has about 1.4 Ci of Cs-137 per gram of U-235. This Cs-137 estimate is consistent with other disposals of irradiated U-235-bearing material in the 1960s. Generally, activities in these shipments were based on measured gamma activity dominated by Cs-137 emitters.

Table 6 shows best-estimate contaminant activities for all of assumed experimental specimen disposals reported in the 1960s. The net Cs-137 for these disposals was 5.4E+02 Ci. This Cs-137 activity is from Table A-11. Contaminant profiles relied on ORIGEN2 analysis of generic zirconium bearing calcine (Wenzel 2000b). It was assumed that the isotopic profile of the above-described waste stream was encompassed by what was calculated for the zirconium calcine. Zirconium calcine was a byproduct from

Table 6. Total best-estimate activity contaminant profiles from Navy-irradiated test specimens for 1952 through 1983[a].

Nuclide	1962 (Ci)	1963 (Ci)	1966 (Ci)	1968 (Ci)	1969 (Ci)	1975 (Ci)
H-3	1.5E-01	4.1E-01	7.1E-01	4.4E-01	2.3E-02	4.5E-02
Be-10	1.5E-09	4.2E-09	7.3E-09	4.5E-09	2.4E-10	4.6E-10
C-14	6.2E-08	1.7E-07	2.9E-07	1.8E-07	9.5E-09	1.8E-08
Co-60	5.5E-02	1.5E-01	2.6E-01	1.6E-01	8.4E-03	1.6E-02
Ni-63	2.6E-02	6.9E-02	1.2E-01	7.4E-02	3.9E-03	7.6E-03
Sr-90	6.1E+01	1.6E+02	2.9E+02	1.8E+02	9.2E+00	1.8E+01
Nb-94	1.2E-08	3.2E-08	5.6E-08	3.4E-08	1.8E-09	3.5E-09
Tc-99	7.7E-03	2.1E-02	3.6E-02	2.2E-02	1.2E-03	2.3E-03
I-129	1.2E-05	3.4E-05	5.9E-05	3.6E-05	1.9E-06	3.7E-06
Cs-137	4.6E+01	1.2E+02	2.2E+02	1.3E+02	7.0E+00	1.4E+01
Eu-152	4.9E-03	1.3E-02	2.3E-02	1.4E-02	7.5E-04	1.5E-03
Eu-154	9.0E-01	2.4E+00	4.3E+00	2.6E+00	1.4E-01	2.7E-01
Pb-210	6.7E-14	1.8E-13	3.2E-13	1.9E-13	1.0E-14	2.0E-14
Ra-226	7.8E-13	2.1E-12	3.7E-12	2.2E-12	1.2E-13	2.3E-13
Ra-228	3.2E-14	8.7E-14	1.5E-13	9.3E-14	4.9E-15	9.5E-15
Ac-227	8.7E-09	2.4E-08	4.1E-08	2.5E-08	1.3E-09	2.6E-09
Th-228	3.3E-07	9.0E-07	1.6E-06	9.6E-07	5.1E-08	9.8E-08
Th-229	2.7E-12	7.4E-12	1.3E-11	7.9E-12	4.2E-13	8.1E-13
Th-230	4.3E-10	1.2E-09	2.0E-09	1.2E-09	6.5E-11	1.3E-10
Th-232	1.1E-13	3.0E-13	5.3E-13	3.2E-13	1.7E-14	3.3E-14
U-232	1.9E-09	5.2E-09	9.1E-09	5.6E-09	2.9E-10	5.7E-10
U-233	2.0E-11	5.5E-11	9.5E-11	5.8E-11	3.1E-12	6.0E-12
U-234	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U-235	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U-236	4.8E-06	1.3E-05	2.3E-05	1.4E-05	7.4E-07	1.4E-06
U-238	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Np-237	8.9E-06	2.4E-05	4.2E-05	2.6E-05	1.4E-06	2.7E-06
Pu-238	4.6E-01	1.3E+00	2.2E+00	1.3E+00	7.1E-02	1.4E-01
Pu-239	5.9E-03	1.6E-02	2.8E-02	1.7E-02	9.0E-04	1.7E-03
Pu-240	5.5E-03	1.5E-02	2.6E-02	1.6E-02	8.3E-04	1.6E-03

Table 6. (continued).

Nuclide	1962 (Ci)	1963 (Ci)	1966 (Ci)	1968 (Ci)	1969 (Ci)	1975 (Ci)
Pu-241	6.5E-01	1.8E+00	3.1E+00	1.9E+00	1.0E-01	1.9E-01
Pu-242	1.2E-05	3.3E-05	5.7E-05	3.5E-05	1.8E-06	3.6E-06
Pu-243	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Pu-244	2.1E-18	5.7E-18	9.9E-18	6.1E-18	3.2E-19	6.2E-19
Am-241	2.7E-02	7.3E-02	1.3E-01	7.7E-02	4.1E-03	7.9E-03
Am-242	1.2E-08	3.4E-08	5.9E-08	3.6E-08	1.9E-09	3.7E-09
Am-243	7.1E-10	1.9E-09	3.4E-09	2.1E-09	1.1E-10	2.1E-10
Cm-242	1.0E-08	2.8E-08	4.9E-08	3.0E-08	1.6E-09	3.1E-09
Cm-243	3.5E-10	9.5E-10	1.7E-09	1.0E-09	5.4E-11	1.0E-10
Cm-244	4.6E-09	1.2E-08	2.2E-08	1.3E-08	7.0E-10	1.4E-09
Cm-245	5.9E-14	1.6E-13	2.8E-13	1.7E-13	9.0E-15	1.8E-14
Cm-246	9.1E-16	2.5E-15	4.3E-15	2.6E-15	1.4E-16	2.7E-16
Cm-247	2.2E-22	5.9E-22	1.0E-21	6.3E-22	3.3E-23	6.5E-23
Cm-248	4.3E-23	1.2E-22	2.0E-22	1.2E-22	6.5E-24	1.3E-23
Total	1.1E+02	2.9E+02	5.1E+02	3.1E+02	1.7E+01	3.2E+01

a. No disposals of Navy irradiated test specimens waste was reported from 1952 to 1962

reprocessing zirconium-clad fuels. The solid calcine nuclide contaminants consist mainly of fission products with disproportionately smaller amounts of actinides. The disproportionately smaller amounts of actinides result from separating enriched uranium from irradiated fission products remaining in the dissolved fuel byproducts. The corresponding amounts of uranium for these disposals (U-234, U-235, U-238) were reported in Section 3.5 of this report.

The principal uncertainties connected with the analysis include unknowns about actual actinide burnups, enrichments, etc. Because of the limited information about these disposals, some bounding assumptions were made to calculate best-estimate activities. More details of this best-estimate analysis and waste stream upper and lower bounding estimates are in Section A-6 of Appendix A. Other contaminants with significantly smaller activities are also in Section A-6 of Appendix A.

3.8 Calcine Disposals

This section reviews the best-estimate inventory for the calcine-contaminated Waste Calcining Facility (WCF) filters shipped from INTEC to the RWMC for disposal between 1964 and 1981. The waste stream corresponding to the calcine filters and other related disposals is INTEC-MOD-5H, shown in Table 2. The principal contaminants in this waste stream are fission products, actinides, and trace amounts of activation products (Berreth 1988). Information used to reassess this waste stream comes from Waste Area Group (WAG) 7 inventory databases, and most importantly from Wenzel (2000b). The WCF review discovered that many COCs were not reported in the disposal records and that distributions of contaminants were incorrectly identified. Also, most of the shipping forms did not report the amount of actinides. Consequently, this reassessment of the WCF disposals relies heavily on ORIGEN2 calculations documented in Wenzel (2000b). A brief discussion of the WCF disposals follows with additional details shown in Appendix E.

During the operation of the WCF between 1964 and 1981, filters from the off-gas system were routinely shipped to RWMC for disposal. Shipping records showed that each shipment had an average activity of ~165 Ci. In the 1960s, these filters were buried in trenches at the SDA. After 1977, these burials shifted to soil vault locations in the SDA. The WCF filters were actually filter assemblies consisting of a fiberglass prefilter in series with a high-efficiency particulate air (HEPA) filter (Wenzel 2000b). Each filter was enclosed in a stainless steel housing. In addition, these filters were shipped to the RWMC from the WCF in a shielded cask. The isotopic distribution of radionuclides in these disposals varied greatly depending on the profile of the waste being processed.

Tables 7 and 8 show the best-estimate cumulative inventory for the disposals of WCF filters from 1964 until 1981. Contaminant activities in Table 7 are based on ORIGEN2 calculations reported in Wenzel (2000b) and scaling factor calculations discussed in Appendix E. Wenzel's calculations were undertaken specifically to update the radioactive inventory data in the buried WCF filters; and are therefore the best inventory data available. Detailed results, including best-estimate, upper bound, and lower bound inventory estimates, computed as a function of disposal time, are in Tables E-6, E-7, and E-8 of Appendix E.

3.9 Sludge Disposals

This section presents a reassessment of contaminant sludge inventories that were previously documented in LMITCO (1995a). This sludge material was extracted from the fuel storage basins at CPP-603. After treatment, the dewatered sludge was sent to the SDA in 43 separate shipments from 1977 through 1980. Other related waste streams from the basins at CPP-603 proved to be insignificant in relation to the reported sludge disposals.[m] This waste stream was identified as item INTEC-MOD-6H in Table 2. The principal contaminants in this waste stream included fission products, actinides, and activation products. It was concluded that this waste stream was isotopically unique and did not easily match nuclide distributions from other waste streams. A brief history of this waste stream follows.

Over a period of 26 years, fuel corrosion and other related events released fuel nuclides, some of which settled on the basin floors. This accumulation—with wind-blown dust—eventually formed a sludge layer 5–10 cm (2–4 in.) thick on the bottom of the basin floor. The basin debris is of three different types: fissile fuel fragments, irradiated metal fragments, and miscellaneous material. The sludge also had ion-exchange properties allowing it to absorb radionuclides already dissolved in the basin water system. Eventually, the sludge became a hazard to personnel and was removed from the basins using a specially designed underwater vacuum system. Later this stored sludge was pumped into several 18 metric-ton steel-lined vaults, where it was dried and solidified. These vaults were sealed and then buried at the SDA. Additional details of this cleanup operation are in Appendix A.

m. Shipping manifests indicate that some expended resins and diatomaceous earth were sent to the SDA. However, only about 100 Ci of gross activity was reported to the SDA from these waste streams. Consequently, these wastes appear as a small fraction of the net contaminants for the basin-related shipments from CPP-603.

Table 7. Best-estimate activity at time of disposal contained within the 183 calcine-contaminated filters shipped from INTEC to RWMC from 1964 through 1981 that is totaled without regard for decay.

Nuclide	Half-life (y)	Scaling Factor	Total Activity (Ci)
H-3	1.233E+01	2.85E-03	1.46E+01
Be-10	1.151E+06	3.81E-11	1.05E-07
C-14	5.730E+03	1.60E-09	4.23E-06
Cl-36	3.010E+05	—	—[b]
Co-60	5.271E+00	1.25E-03	1.11E+01
Ni-59	7.600E+04	3.34E-06	1.17E-02
Ni-63	1.001E+02	2.27E-04	6.32E-01
Sr-90	2.878E+01	1.01E+00	3.64E+03
Nb-94	2.030E+04	3.09E-10	8.06E-07
Tc-99	2.111E+05	1.98E-04	5.15E-01
I-129	1.570E+07	3.20E-07	8.37E-04
Cs-137	3.007E+01	1.00E+00	3.50E+03
Eu-152	1.354E+01	7.10E-05	3.18E-01
Eu-154	8.593E+00	1.30E-02	8.14E+01
Pb-210	2.230E+01	2.60E-12	9.12E-09
Ra-226	1.600E+03	3.68E-10	9.80E-07
Ra-228	5.750E+00	5.56E-14	9.86E-10
Ac-227	2.180E+01	9.56E-11	3.35E-07
Th-228	1.910E+00	1.72E-05	6.01E-02
Th-229	7.300E+03	7.90E-13	2.77E-09
Th-230	7.540E+04	1.38E-09	4.83E-06
Th-232	1.400E+10	2.59E-15	9.07E-12
Pa-231	3.280E+04	2.52E-10	8.80E-07
U-232	6.890E+01	3.47E-08	9.63E-05
U-233	1.592E+05	4.96E-11	1.33E-07
U-234	2.455E+05	3.51E-06	9.17E-03
U-235	7.038E+08	2.29E-08	6.03E-05
U-236	2.342E+07	5.72E-08	1.53E-04
U-238	4.470E+09	1.18E-09	3.09E-06
Np-237	2.144E+06	3.43E-07	9.00E-04
Pu-238	8.770E+01	4.17E-03	1.18E+01
Pu-239	2.411E+04	6.86E-05	1.80E-01
Pu-240	6.563E+03	5.34E-05	1.43E-01

Table 7. (continued).

Nuclide	Half-life (y)	Scaling Factor	Total Activity (Ci)
Pu-241	1.435E+01	6.07E-03	2.57E+01
Pu-242	3.733E+05	1.11E-07	2.92E-04
Pu-244	8.080E+07	1.68E-15	4.41E-12
Am-241	4.322E+02	2.96E-04	7.58E-01
Am-243	7.370E+03	2.80E-06	1.91E-03
Cm-243	2.910E+01	8.86E-08	3.10E-04
Cm-244	1.810E+01	5.45E-06	1.91E-02
Cm-245	8.500E+03	4.93E-10	1.72E-06
Cm-246	4.760E+03	3.91E-11	1.37E-07
Cm-247	1.560E+07	5.05E-17	1.77E-13
Cm-248	3.480E+05	6.13E-17	2.15E-13

a. Computed at the time of disposal.

b. It was not possible to estimate a Cl-36 inventory in the calcine or WCF filters. However, it is believed that the Cl-36 inventory is very small, probably smaller than the C-14 activity.

Table 8. Best-estimate total activity at time of disposal contained within the 183 calcine-contaminated filters shipped from INTEC to RWMC.

Year	Inventory (Ci)	Year	Inventory (Ci)	Year	Inventory (Ci)
1964	1.07E+03	1970	9.84E+00	1976	2.47E+02
1965	0.00E+00	1971	1.59E+02	1977	3.01E+02
1966	2.78E+02	1972	2.67E+02	1978	1.51E+03
1967	8.79E+02	1973	2.28E+02	1979	6.29E+02
1968	7.45E+01	1974	3.56E+02	1980	4.26E+02
1969	3.25E+02	1975	1.88E+02	1981	3.42E+02

Review of the sludge disposals relied on reported activities taken from Form 110s, RWMIS data, and supporting documentation given in LMITCO (1995a). During the reassessment review of reported sludge disposal inventories it was discovered that—for a particular disposal year—isotopic distributions, net activities, and container weights were identical in many of the shipping manifests. It is unlikely that each reported disposal was actually identical. The conclusion is that some procedure for averaging the assays was developed and uniformly applied to all of the shipments for a particular reporting period. It was also concluded that significant uncertainties were introduced by using this uniform reporting method. In addition, because of different reporting criteria standards a number of COCs required for the final SDA risk assessment were not reported. Consequently, the reassessment required that scaling factors be developed to account for these unreported contaminants.

To reassess the contaminants reported in RWMIS and the HDT, other supporting documents were located to identify data on nuclide assays from sludge First, this 1973 assay data (Smith 1974) was used to crosscheck HDT reported total activities and isotopic profiles (LMITCO 1995a). Second, net weights of the contaminated sludge from this same assay data were cross-checked with weights of HDT sludge disposals. The weights of the basin sludge disposal matched the net activities sent to the SDA. Additionally, cleanup systems using both resin and diatomaceous earth were used for the water purification systems in the basins at CPP-603. However, the gross activities of these disposals were only a small fraction of the net activity disposals for the sludge burials. The reassessment concludes that net reported actinide contaminant activities were under-estimated and that fission contaminants were over-calculated. These results combine known data about concentrations of sludge assay contaminants from the storage basins with estimated amounts of sludge actually sent to the SDA. Best-estimate amounts of contaminants associated with the sludge disposals are in Table 9. Additional details of the best-estimate contaminant analysis for the sludge disposals are in Section A-11 of Appendix A. Moreover, upper and lower bounds for contaminant activities are in the appendix analysis.

Table 9. Total best-estimate activity for CPP-603 storage basin sludge disposals from 1952 through 1983.[a]

Nuclide	1977 Ci	1978 Ci	1979 Ci	1980 Ci
H-3	2.6E+00	1.2E+00	5.8E-01	7.5E+00
Be-10	3.5E-08	1.5E-08	7.7E-09	1.0E-07
C-14	2.5E-03	1.1E-03	5.5E-04	7.1E-03
Cl-36	1.3E-06	5.9E-07	3.0E-07	3.8E-06
Co-60	1.5E+02	6.8E+01	3.4E+01	4.4E+02
Ni-59	1.4E-02	6.0E-03	3.0E-03	3.9E-02
Ni-63	1.0E+00	4.5E-01	2.2E-01	2.9E+00
Sr-90	9.2E+02	4.1E+02	2.1E+02	2.7E+03
Nb-94	5.6E-04	2.5E-04	1.2E-04	1.6E-03
Tc-99	1.8E-01	8.0E-02	4.0E-02	5.2E-01
I-129	2.9E-04	1.3E-04	6.5E-05	8.4E-04
Cs-137	9.1E+02	4.1E+02	2.0E+02	2.6E+03
Eu-152	6.5E-02	2.9E-02	1.4E-02	1.9E-01
Eu-154	1.2E+01	5.3E+00	2.6E+00	3.4E+01
Pb-210	4.2E-10	1.8E-10	9.2E-11	1.2E-09
Ra-226	1.0E-08	4.6E-09	2.3E-09	3.0E-08
Ra-228	6.7E-14	3.0E-14	1.5E-14	1.9E-13
Ac-227	5.9E-08	2.6E-08	1.3E-08	1.7E-07
Th-228	4.6E-05	2.0E-05	1.0E-05	1.3E-04
Th-229	1.3E-09	5.6E-10	2.8E-10	3.7E-09

Table 9. (continued).

Nuclide	1977 Ci	1978 Ci	1979 Ci	1980 Ci
Th-230	1.2E-05	5.4E-06	2.7E-06	3.5E-05
Th-232	4.0E-13	1.8E-13	9.0E-14	1.2E-12
PA231	9.7E-07	4.3E-07	2.2E-07	2.8E-06
U-232	6.4E-05	2.9E-05	1.4E-05	1.9E-04
U-233	2.4E-06	1.1E-06	5.4E-07	7.0E-06
U-234	3.4E-01	1.5E-01	7.6E-02	9.9E-01
U-235	1.2E-02	5.2E-03	2.6E-03	3.4E-02
U-236	2.3E-03	1.0E-03	5.0E-04	6.6E-03
U-238	1.6E-03	7.3E-04	3.6E-04	4.7E-03
Np-237	1.7E-04	7.6E-05	3.8E-05	4.9E-04
Pu-238	2.3E-02	1.0E-02	5.0E-03	6.5E-02
Pu-239	9.2E-01	4.1E-01	2.0E-01	2.6E+00
Pu-240	6.8E-03	3.0E-03	1.5E-03	2.0E-02
Pu-241	4.1E-03	1.8E-03	9.1E-04	1.2E-02
Pu-242	1.7E-10	7.6E-11	3.8E-11	5.0E-10
Pu-244	2.0E-21	8.9E-22	4.4E-22	5.8E-21
Am-241	2.3E-05	1.0E-05	5.1E-06	6.6E-05
Am-243	7.1E-12	3.1E-12	1.6E-12	2.0E-11
Cm-243	1.7E-11	7.4E-12	3.7E-12	4.8E-11
Cm-244	3.6E-12	1.6E-12	8.0E-13	1.0E-11
Cm-245	8.8E-18	3.9E-18	1.9E-18	2.5E-17
Cm-246	5.2E-21	2.3E-21	1.2E-21	1.5E-20
Cm-247	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cm-248	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Total	2.00E+03	8.96E+02	4.48E+02	5.79E+03

a. Sludge disposals did not begin until 1977.

3.10 Tank Farm Soil

This section presents a reassessment of contaminant soil inventories that were previously documented in LMITCO (1995a). Typically this class of soil disposals was associated with large-scale excavations of contaminated Tank Farm sites, with the removed dirt being sent to the SDA.[n] This waste stream is item INTEC-MOD-7H in Table 2. The principal contaminants in this waste stream included significant amounts of fission products, with actinides and traces of activation products. It was concluded that this waste stream was isotopically similar to the calcine waste disposals discussed in Section 3.8.

Contaminated soil in this waste stream—formerly simply added to general plant waste streams (see Table 2)—should be differentiated from other classes of contaminated soil because the other classes were generally either low net activity or low activity small-scale shipments whose sources were non-Tank Farm LLW liquid.[o] In contrast, most activity from Tank Farm cleanup activity was associated with leaks of high-level waste (HLW).

Approximately 3.6E3 metric tons of contaminated soil sent from INTEC to the SDA was associated with Tank Farm leaks. None of the leaks came from a breach of the eleven tanks that stored liquid raffinates, but rather from transfer lines that inter-connected these tanks to each other or to other plant reprocessing facilities. Of the approximately 5.7E+03 Ci reported sent to the SDA from 1974 through 1983, about 97% of the activity was associated with two releases of HLW liquid raffinate from the mid 1970s (from 1974 through 1975 see Table A-25). Other much smaller secondary sources of contaminated soil were associated with related ground releases of Tank Farm LLW liquid.[p] Shipping information from RWMIS showed that 3.6E+03 metric tons of contaminated dirt were sent to the SDA from 1974 through 1983. This mass of soil includes in many cases both excavated contaminated dirt and uncontaminated dirt with which it was mixed to minimize radiation field exposure during transport to the SDA.

Review of this waste stream relied on available Form 110 shipping manifests, WAG 7 databases, and other supporting references (WINCO 1993). Known shipping data were crosschecked with other external documents for consistency in reporting the contaminated soil activities sent to the SDA. It proved impractical to analyze all known soil shipments of contaminated soil connected with LLW releases. Consequently these reported disposals were isotopically scaled to the dominant HLW activities for disposals connected with large-scale excavations. Again most of the activity of interest was sent to the SDA between 1974 and 1975.

Two important findings were made in conjunction with the reassessment of reported contaminants is the soil disposal inventories. The first is that reassessment of the contaminated soil shipping data from both RWMIS data and later reported inventory reports (LMITCO 1995a) showed that a number of key contaminants of concern had not been reported (because of different reporting criteria at that time). These contaminants included long-lived fission nuclides like Tc-99 and I-129; also actinide contaminants were generally not reported. Second, the reported distribution of fission product isotopes was not

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n. In some circumstances contaminated soil was left in place or excavated and sent to locations other than the SDA. Large-scale excavations are defined as more than 10 cubic yards.

o. Not all radioactive soil disposals were clearly documented. This is especially true of early disposals that occurred in the 1950s. As an example, in 1958 a HEPA filter was breached at CPP-603. The airborne contaminants settled on the ground, resulting in about 60 truckloads of excavated soil being sent to the SDA. However, it was concluded that the net activity from this event was very low compared to the soil removals from the later raffinate spills.

p. Some Tank Farm leaking transfer lines were used for transferring both HLW and LLW.

representative. That is, the reported nuclide distributions were not representative of fission products found in raffinates (Palmer et al. 1998), fuels (Wenzel 2000a), or calcine material (Wenzel 2000b). More details are in Appendix A.

Because of limited information associated with shipping manifests, the reassessed contaminant profiles were calculated using estimated volumes of leaked HLW raffinates that were released in two incidents occurring in 1974 (WINCO 1993). The first event was discovery of a broken transfer line in 1974; estimates were that no more than 100 gal of HLW were released to the surrounding soil. A second breached line was discovered with an estimated 3,600-gal release of HLW. Unlike the first leak, the second leak was the consequence of a small hole that had been in the transfer line since 1955. Excavation and clean up of these two sites was extensive, disposals from the first cleanup site was finished in 1983. The second spill site was only partially excavated because of high radiation fields. After the excavations were completed, these sites were backfilled with uncontaminated earth. Additional detail about these specific ground releases is in Appendix A.

The principal uncertainties in estimating contaminant inventories associated with Tank Farm disposals lie in knowing actual amounts of spilled raffinates and what fraction of this material was then excavated and sent to the SDA. Narratives of the cleanup activities make known that in the case of the nominal 100- spill, virtually all of the associated contaminated soil was sent to the SDA. In the case of the 3,600-gal spill, the fraction of contaminates excavated from the spill site was estimated to range from 8.0E+01 to 9.0E+02 of equivalent gallons of spilled raffinates. This wide range of possible equivalent volumes is the result of limited information about the partial excavation volume of removed soil. The reported depth of this site was 6.5 ft (removed topsoil) with an uncertainty of 0.5 ft for the actual excavation depth. The 6.5-ft depth corresponded to the approximate location of the transfer line leak. Because the radionuclide concentrations in the vicinity of the 6.5-ft reference depth were highly peaked below the depth of 6 ft, the amount of equivalent contaminants became disproportionately large in the localized region around the identified leak zone.

The best estimate of the equivalent leaked volume that was excavated is calculated to be 300 gal. More details of how the equivalent volumes were calculated are in Appendix A. Converting the best-estimate volume to an equivalent reference activity conservatively assumed 9 Ci/gal of Cs-137 (WINCO 1993). Then the equivalent best-estimate reference activity equals 2.7E+03 Ci of Cs-137. The corresponding best-estimate distribution of activity assumed the identical scaling factors for the calcine disposals discussed in Section 3.8.[q] Table 10 shows the corresponding best-estimate activities for the disposals of Tank Farm soil. As noted from the above discussion, the actual amount of excavated contaminated dirt from the 3,600-gal spill site was highly uncertain. These uncertainties were factored into the associated lower- and upper-bound estimates in Appendix A.

q. Recall that the calcine is processed and stabilized raffinate liquid.

Table 10. Total best-estimate activity for Tank Farm-related soil disposals from 1952 through 1983.

Nuclide	1974 (Ci)	1975 (Ci)	1976 (Ci)	1977 (Ci)	1978 (Ci)	1983 (Ci)
H-3	5.4E+00	2.2E+00	6.9E-02	1.6E-01	3.6E-02	3.6E-02
Be-10	7.3E-08	2.9E-08	9.2E-10	2.1E-09	4.8E-10	4.8E-10
C-14	3.1E-06	1.2E-06	3.9E-08	8.9E-08	2.0E-08	2.0E-08
Cl-36	—	—	—	—	—	—
Co-60	2.4E+00	9.5E-01	3.0E-02	6.9E-02	1.6E-02	1.6E-02
Ni-59	6.4E-03	2.6E-03	8.1E-05	1.9E-04	4.2E-05	4.2E-05
Ni-63	4.3E-01	1.7E-01	5.5E-03	1.3E-02	2.9E-03	2.8E-03
Sr-90	1.9E+03	7.7E+02	2.5E+01	5.6E+01	1.3E+01	1.3E+01
Nb-94	5.9E-07	2.4E-07	7.5E-09	1.7E-08	3.9E-09	3.9E-09
Tc-99	3.8E-01	1.5E-01	4.8E-03	1.1E-02	2.5E-03	2.5E-03
I-129	6.1E-04	2.4E-04	7.7E-06	1.8E-05	4.1E-06	4.0E-06
Cs-137	1.9E+03	7.6E+02	2.4E+01	5.5E+01	1.3E+01	1.3E+01
Eu-152	1.4E-01	5.4E-02	1.7E-03	3.9E-03	9.0E-04	8.9E-04
Eu-154	2.5E+01	9.9E+00	3.1E-01	7.2E-01	1.6E-01	1.6E-01
Pb-210	5.0E-09	2.0E-09	6.3E-11	1.4E-10	3.3E-11	3.3E-11
Ra-226	7.0E-07	2.8E-07	8.9E-09	2.0E-08	4.7E-09	4.6E-09
Ra-228	1.1E-10	4.2E-11	1.3E-12	3.1E-12	7.0E-13	7.0E-13
Ac-227	1.8E-07	7.3E-08	2.3E-09	5.3E-09	1.2E-09	1.2E-09
Th-228	3.3E-02	1.3E-02	4.1E-04	9.5E-04	2.2E-04	2.1E-04
Th-229	1.5E-09	6.0E-10	1.9E-11	4.4E-11	1.0E-11	9.9E-12
Th-230	2.6E-06	1.1E-06	3.3E-08	7.6E-08	1.7E-08	1.7E-08
Th-232	4.9E-12	2.0E-12	6.3E-14	1.4E-13	3.3E-14	3.2E-14
Pa-231	4.8E-07	1.9E-07	6.1E-09	1.4E-08	3.2E-09	3.1E-09
U-232	6.6E-05	2.6E-05	8.4E-07	1.9E-06	4.4E-07	4.3E-07
U-233	9.4E-08	3.8E-08	1.2E-09	2.7E-09	6.3E-10	6.2E-10
U-234	6.7E-03	2.7E-03	8.5E-05	1.9E-04	4.4E-05	4.4E-05
U-235	4.4E-05	1.7E-05	5.5E-07	1.3E-06	2.9E-07	2.9E-07
U-236	1.1E-04	4.4E-05	1.4E-06	3.2E-06	7.2E-07	7.2E-07
U-238	2.3E-06	9.0E-07	2.9E-08	6.6E-08	1.5E-08	1.5E-08
Np-237	6.5E-04	2.6E-04	8.3E-06	1.9E-05	4.3E-06	4.3E-06
Pu-238	7.9E+00	3.2E+00	1.0E-01	2.3E-01	5.3E-02	5.2E-02
Pu-239	1.3E-01	5.2E-02	1.7E-03	3.8E-03	8.7E-04	8.6E-04
Pu-240	1.0E-01	4.1E-02	1.3E-03	3.0E-03	6.8E-04	6.7E-04
Pu-241	1.2E+01	4.6E+00	1.5E-01	3.4E-01	7.7E-02	7.6E-02
Pu-242	2.1E-04	8.4E-05	2.7E-06	6.1E-06	1.4E-06	1.4E-06
Pu-244	3.2E-12	1.3E-12	4.1E-14	9.3E-14	2.1E-14	2.1E-14
Am-241	5.6E-01	2.3E-01	7.2E-03	1.6E-02	3.7E-03	3.7E-03
Am-243	5.3E-03	2.1E-03	6.8E-05	1.6E-04	3.5E-05	3.5E-05
Cm-243	1.7E-04	6.8E-05	2.1E-06	4.9E-06	1.1E-06	1.1E-06
Cm-244	1.0E-02	4.2E-03	1.3E-04	3.0E-04	6.9E-05	6.8E-05
Cm-245	9.4E-07	3.8E-07	1.2E-08	2.7E-08	6.2E-09	6.2E-09
Cm-246	7.5E-08	3.0E-08	9.5E-10	2.2E-09	4.9E-10	4.9E-10
Cm-247	9.6E-14	3.9E-14	1.2E-15	2.8E-15	6.4E-16	6.3E-16
Cm-248	1.2E-13	4.7E-14	1.5E-15	3.4E-15	7.8E-16	7.7E-16
Total	3.85E+03	1.55E+03	4.97E+01	1.13E+02	2.64E+01	2.64E+01

3.11 Irradiated Hardware

Nearly all of the activation product waste generated at INTEC from fuel reprocessing activities and later sent to the SDA for disposal was produced from neutron-activated stainless steel hardware (alloys 304 and 316) associated with EBR-II subassemblies.[r] Details of the computer calculations and the results relating to the radionuclide inventory in the stainless steel hardware from EBR-II is in Appendix C. In general, Table-11 shows the cumulative summary of lower-bound, best-estimate, and upper-bound estimates of the inventory of activation product waste from fuel reprocessing at INTEC that was buried in the SDA. This information spans 1952 through 1983 and comes from the analysis in Appendix C. The upper-bound and lower-bound estimates are each a factor of two of the Best-Estimate values. A review of the disposal records determined that after 1983, no significant burials of activated metal from INTEC were made in the SDA.

Irradiated subassembly hardware sent to the SDA from 1977 through 1983 represents the bulk of the buried activation products identified during the time addressed in the HDT (1952 through 1983). Records from the RWMIS database document hundreds of waste shipments, most of which contain only trace activation-product contaminants; however, the activated products in this waste are less than 1% of the contaminants in the shipments of subassembly hardware from EBR-II. As in later shipments made during the time addressed in the RPDT (1984–2003), the material composition of the subassembly components was primarily 304 and 316 stainless steels. The HDT inventories are in Table 11 with the current best-estimate analysis.

Radionuclides with relatively short half-lives (e.g., less than Co-60) are not included in the present analysis. For example, the principal radionuclides in activated steel fall into two main groups. Those radionuclides with short half-lives (less than a year), especially those with a relatively low radiotoxicity, belong to one group; and those radionuclides with a relatively long half-life (e.g., greater than 5 years) and a high radiotoxicity belong to the second group. For example, Cr-51 (28 days), Co-58 (71 days), Fe-59 (44 days), and Mn-54 (312 days) are activation products with short half-lives and moderate to low radiotoxicities. These radionuclides were mainly considered in the HDT and RPDT analyses, but were not considered in the present analysis. However, the long-lived activation products are more important to defining the long-term inventory and radiological risk for the SDA; and these radionuclides are C-14 (5,730 years), Cl-36 (301,000 years), Co-60 (5.27 years), Ni-59 (76,000 years), Ni-63 (100 years), Nb-94 (20,000 years), and Tc-99 (213,000 years). It is the purpose of the present best-estimate analysis to determine the inventory of the long-lived radionuclides, and neglect the inventory associated with the short-lived isotopes.

The data in Table 11 were obtained from the calculated inventory results in Table C-8, and other tables in Appendix C. The INTEC reprocessing dates for the four major electrolytic dissolution campaigns (see Bjorklund, Offutt, and Denney 1974; Mortimer 1978, 1981; or Houston, Jonas, and Wendt 1991) are not necessarily the same as the disposal dates given for activated metal listed in the RWMIS database (e.g., hardware processed in one year may have been retained at INTEC for a period of time and then disposed of in a different year). Consequently, some of the calculated inventory data has been redistributed into estimated disposal dates, as follows.

r. From the second electrolytic dissolution campaign report (Figure 1, page 2 of Mortimer), it is noted that some stainless steel scrap metal and other miscellaneous fuels from TAN were processed at INTEC with EBR-II subassemblies; however, the TAN material appears to be small compared with the EBR-II metal mass, and it may not have been irradiated (i.e., only contained irradiated UO_2 fuel); and was therefore neglected in the activated metal analysis.

- All of the hardware associated with the first electrolytic dissolution campaign, which occurred in 1973, is assumed to have been disposed of at the SDA in 1973. This assumption is slightly conservative since some stainless steel hardware was dissolved at INTEC (e.g., included in calcine wastes) and therefore was not sent to the SDA.
- All of the hardware that was processed at INTEC from 1975 through 1976, which includes the second electrolytic dissolution campaign, is assumed to have been disposed of at the SDA in 1975 and 1977; 50% in each year.
- All of the structural hardware that was processed at INTEC in 1977 is modeled as if it were disposed of at the SDA in waste shipments made in 1981 and 1982; 50% in each year.
- All of the EBR-II fuel that was reprocessed at INTEC from 1981 to 1982 was completely dissolved (e.g., this fuel contained metallic uranium and stainless steel cladding, but no structural components).

Therefore, no activated metal waste from the fourth electrolytic dissolution campaign is believed to have been disposed of at the SDA. Table 11 shows the best-estimate inventory of activated metals that are estimated to have been disposed of at the SDA as a function of disposal dates. To determine the upper-bound estimates corresponding to the Table 11 data, these data should be multiplied by a factor of two. To determine the lower-bound values, the Table 11 data should be divided by two.

Table 11. Best-estimate of the inventory of EBR-II stainless steel hardware disposals from 1952 through 1983.

Isotope	Half-life (years)	1973 (Ci)	1975 (Ci)	1977 (Ci)	1981 (Ci)	1982 (Ci)	Total (Ci)
H-3	1.23E+01	—	—	—	—	—	—
Be-10	1.60E+06	—	—	—	—	—	—
C-14	5.73E+03	4.74E-01	6.80E-01	6.80E-01	3.63E-01	3.63E-01	2.56E+00
Cl-36	3.01E+05	2.56E-04	3.83E-04	3.83E-04	1.91E-04	1.91E-04	1.40E-03
Co-60	5.27E+00	3.06E+04	4.38E+04	4.38E+04	2.35E+04	2.35E+04	1.65E+05
Ni-59	7.60E+04	2.08E+00	2.99E+00	2.99E+00	1.60E+00	1.60E+00	1.13E+01
Ni-63	1.00E+02	1.55E+02	2.22E+02	2.22E+02	1.19E+02	1.19E+02	8.37E+02
Nb-94	2.00E+04	1.08E-01	1.55E-01	1.55E-01	8.30E-02	8.30E-02	5.84E-01
Tc-99	2.13E+05	5.30E-02	7.50E-02	7.50E-02	4.05E-02	4.05E-02	2.84E-01
Total (Ci)		3.08E+04	4.40E+04	4.40E+04	2.36E+04	2.36E+04	1.66E+05

3.12 General Plant Waste

The purpose of this section is to summarize the results of calculations made for the final radioactive waste stream resulting from INTEC operations. This waste stream is general plant waste (GPW) and is identified as INTEC-MOD-9H. In brief, GPW consists of all radioactive items that have not been incorporated in any of the other previously identified waste streams. These wastes are generally both compactable and noncompactable materials. Compactable material includes those items such as cloth, paper, and plastic. Noncompactable materials consist of miscellaneous wastes (e.g., radioactive sources), contaminated concrete, metal, building materials, fuel charging casks, lead, and those items that were contaminated with other radioactive materials (e.g., calcine material). Both fission products and actinides can be found in GPW; however, both types of radionuclides are usually found at lower concentrations than generally found in other waste streams. In the first decade of the HDT period, limited documentation is available for material sent from INTEC to the SDA. The first available documentation of GPW begins in 1959. The gross activity for the GPW waste stream was determined from waste shipment records, or WAG 7 inventory databases. The total activities associated with GPW were calculated as the total reported activity minus other waste streams that have already been identified and taken into account. Table 12 shows the calculated yearly activities associated with general plant waste and its estimated Cs-137 activity. Note that for 1959 through 1970,[s] the estimated Cs-137 activity is equal to the total GPW activity. However, from 1971 through 1983, the Cs-137 activity is estimated to be 25% of the total gross activity. The reason for these different assumptions is based on the following observations: (1) the total reported activities during the early years appears to be based on measured gross-gamma activities, and these data would have been primarily associated with the activity from Cs-137; (2) the reported activities from 1971 through 1983 appear to be associated with radioactive materials whose total activity (including both gamma and beta activities) was estimated (not measured). Therefore, the Cs-137 inventory in mixed fission product (MFP) waste is only a fraction of the total reported activity. Over a long period of time, the Cs-137 activity in radioactive fuel (or calcine material) averages about 25% of the total activity. This information is summarized in Table 13. Therefore, the Cs-137 activity in general plant waste from 1971 through 1983 was estimated to be 25% of the total reported activity.

Once the Cs-137 inventory in the general plant waste stream has been estimated, the activity of other radionuclides can be determined by multiplying the estimated Cs-137 activity by the corresponding best-estimate scaling factors as previously discussed in Section 3.8, and shown in Column 2 of Table 14. The best-estimate cumulative activity results (from 1959 through 1983) are summarized in Table 14. The lower-bound (and upper-bound) activity results were calculated by dividing (or multiplying) the best-estimate results by a factor of 1.5.

3.13 Summary of Revised Inventory for 1952 through 1983

The nine key waste streams that were defined in Table 2[t] included several that contained significant amounts of fission products (calcine, sludge, Vycor glass, and Tank Farm soil), other streams contained varying amounts of actinides (acid pit disposals, irradiated fuel samples, and bulk uranium disposals), and one stream contained significant amounts of activation products (irradiated subassembly hardware). General plant waste disposals consisted mainly of contact handled LLW. The composite estimates were based on waste stream specific scaling factors that were either referenced to Cs-137 and some cases U-235. The rationale for using differing uncertainty multipliers for each stream was previously discussed in Sections 3.4 to 3.12 and the supporting information in the appendices. Lower-bound, best-estimate, and upper-bound activities were calculated by separately summing the activities of the nine separate waste streams. These lower-bound, best-estimate, and upper-bound activities are addressed in each of their respective appendices to this report and summarized in Appendix F.

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s. GPW records were not kept from 1952 through 1959.

t. The nine streams of interest were acid pit disposals, actinide materials, irradiated fuel samples, Vycor glass, calcine filters, CPP-603 basin sludge, contaminated Tank Farm soil, irradiated hardware, and general plant waste.

Table 12. Total activity in INTEC general plant waste buried in the SDA and the estimated Cs-137 activity in this waste stream from 1959 through 1983.[a]

Disposal Date	General Plant Waste Total Activity (Ci)	Estimated Cs-137 Activity (Ci)	Comments
1959	2.8E+02	2.8E+02	Cs-137=100% GPW activity
1960	8.6E+01	8.6E+01	Cs-137=100% GPW activity
1961	2.1E+02	2.1E+02	Cs-137=100% GPW activity
1962	1.6E+02	1.6E+02	Cs-137=100% GPW activity
1963	2.3E+02	2.3E+02	Cs-137=100% GPW activity
1964	2.3E+02	2.3E+02	Cs-137=100% GPW activity
1965	1.7E+02	1.7E+02	Cs-137=100% GPW activity
1966	2.3E+02	2.3E+02	Cs-137=100% GPW activity
1967	3.4E+02	3.4E+02	Cs-137=100% GPW activity
1968	1.0E+02	1.0E+02	Cs-137=100% GPW activity
1969	5.7E+02	5.7E+02	Cs-137=100% GPW activity
1970	1.0E+02	1.0E+02	Cs-137=100% GPW activity
Subtotal 1959–70	2.7E+03	2.7E+03	
1971	6.9E+01	1.7E+01	Cs-137=25% GPW activity
1972	1.5E+02	3.7E+01	Cs-137=25% GPW activity
1973	5.1E+01	1.3E+01	Cs-137=25% GPW activity
1974	2.5E+02	6.3E+01	Cs-137=25% GPW activity
1975	2.0E+01	5.1E+00	Cs-137=25% GPW activity
1976	9.8E+01	2.4E+01	Cs-137=25% GPW activity
1977	7.5E+02	1.9E+02	Cs-137=25% GPW activity
1978	1.8E+03	4.5E+02	Cs-137=25% GPW activity
1979	6.3E+02	1.6E+02	Cs-137=25% GPW activity plus a ~0.15 Ci radium source
1980	3.0E+02	7.5E+01	Cs-137=25% GPW activity
1981	3.7E+02	9.4E+01	Cs-137=25% GPW activity
1982	1.7E+02	4.2E+01	Cs-137=25% GPW activity
1983	3.0E+02	7.6E+01	Cs-137=25% GPW activity
Subtotal 1971–83	4.9E+03	1.2E+03	Cs-137=25% GPW activity
Grand Total	**7.7E+03**	**4.0E+03**	

a. GPW records do not begin until 1959.

Table 13. Ratio of Cs-137 activity to the total activity (fission products + actinides) in irradiated fuel as a function of decay time.

Decay Time (years)	Ratio of Cs-137 to Total Fuel Activity (Ci/Ci)
5.0	15%
10.0	23%
20.0	25%
50.0	26%
200.0	27%
Average	~25%

Results are based on ORIGEN2 calculations performed on pressurized water reactor fuel irradiated for 1 year and then decayed for the indicated time periods.

Table 14. Cumulative activity in the General Plant Waste stream from 1959 through 1983.[a]

Nuclide	Applied Scaling Factors	Cumulative Activity (Ci)
H-3	2.8E-03	1.1E+01
Be-10	3.8E-11	1.5E-07
C-14	1.6E-09	6.3E-06
Cl-36	—	—
Co-60	1.2E-03	4.9E+00
Ni-59	3.3E-06	1.3E-02
Ni-63	2.3E-04	9.0E-01
Sr-90	1.0E+00	4.0E+03
Nb-94	3.1E-10	1.2E-06
Tc-99	2.0E-04	7.8E-01
I-129	3.2E-07	1.3E-03
Cs-137	1.0E+00	4.0E+03
Eu-152	7.1E-05	2.8E-01
Eu-154	1.3E-02	5.1E+01
Pb-210	2.6E-12	1.0E-08
Ra-226	3.7E-10	1.5E-01
Ra-228	5.6E-14	2.2E-10
Ac-227	9.6E-11	3.8E-07
Th-228	1.7E-05	6.8E-02
Th-229	7.9E-13	3.1E-09
Th-230	1.4E-09	5.5E-06
Th-232	2.6E-15	1.0E-11
Pa-231	2.5E-10	1.0E-06
U-232	3.5E-08	1.4E-04
U-233	5.0E-11	2.0E-07
U-234	3.5E-06	1.4E-02
U-235	2.3E-08	9.1E-05
U-236	5.7E-08	2.3E-04
U-238	1.2E-09	4.7E-06

Table 14. (Continued.)

Nuclide	Applied Scaling Factors	Cumulative Activity (Ci)
Np-237	3.4E-07	1.4E-03
Pu-238	4.2E-03	1.7E+01
Pu-239	6.9E-05	2.7E-01
Pu-240	5.3E-05	2.1E-01
Pu-241	6.1E-03	2.4E+01
Pu-242	1.1E-07	4.4E-04
Pu-244	1.7E-15	6.6E-12
Am-241	3.0E-04	1.2E+00
Am-243	2.8E-06	1.1E-02
Cm-243	8.9E-08	3.5E-04
Cm-244	5.4E-06	2.2E-02
Cm-245	4.9E-10	1.9E-06
Cm-246	3.9E-11	1.5E-07
Cm-247	5.1E-17	2.0E-13
Cm-248	6.1E-17	2.4E-13
Totals	2.0E+00	8.1E+03

a. GPW records do not begin until 1959.

Comparisons were also made between the reassessed net HDT activities and previously reported HDT activities (LMITCO 1995a). Other fission contaminants of concern like I-129 were not reported in the earlier inventory analysis. Generally, the reassessed best estimate of inventory activation products were in agreement with previously reported activities (with the exception of C-14 and Nb-94). Reassessed Cs-137 fission product activities were about a factor of two larger than previous estimates. The higher Cs-137 activities were the mainly the consequence of activities reassessed for WCF disposals, Tank Farm soil disposals, and Vycor glass disposals. Reassessed TRU contaminants were also higher. These differences were the result of accounting for TRU in Vycor glass disposals and calcine disposals that were not reported in the HDT (LMITCO 1995a). Also, the reassessed TRU activities for disposed Tank Farm contaminated soils were higher than given in the original inventory report. Table 15 summarizes revised waste streams.

3.14 Uncertainties

Disposals of waste streams containing activation products, fission products, and actinide products were all affected by inherent uncertainties in documentation. There were also other factors contributing to uncertainties in estimating actual contaminant activities. The major contributors are uncertainties due to:

1. Reporting of irradiation histories and materials compositions
2. Undocumented materials dispositions
3. Results of ORIGEN scaling factors (caused by other uncertainties such as cross-sections and decay times)
4. Measurements of activities in reported waste streams[u]

u. Some indirect measurement techniques for high activity shipments had errors that underestimated disposals by as much as a factor of ten.

Table 15. Revised best estimate of INTEC waste streams from 1952 through 1983.

Nuclide	Acid Pit (Ci)	Solid Actinides (Ci)	Navy Disposals (Ci)	Vycor Glass (Ci)	Calcine (Ci)	Sludge (Ci)	Tank Farm Soil (Ci)	Irradiated Hardware (Ci)	General Plant Waste (Ci)	Total
H-3			1.8E+00	3.4E+02	1.5E+01	1.2E+01	7.9E+00		5.6E+00	3.8E+02
Be-10			1.8E-08	1.4E-06	1.0E-07	1.6E-07	1.1E-07		7.5E-08	1.9E-06
C-14			7.3E-07	5.7E-05	4.2E-06	1.1E-02	4.4E-06	2.6E+00	3.2E-06	2.6E+00
Cl-36					—	6.1E-06		1.4E-03	0.0E+00	1.4E-03
Co- 60			6.5E-01		1.1E+01	7.0E+02	3.5E+00	1.6E+05	2.5E+00	1.6E+05
Ni-59					1.2E-02	6.2E-02	9.3E-03	1.1E+01	6.6E-03	1.1E+01
Ni-63			3.0E-01		6.3E-01	4.6E+00	6.3E-01	8.4E+02	4.5E-01	8.5E+02
Sr-90			7.1E+02	4.2E+04	3.6E+03	4.2E+03	2.8E+03		2.0E+03	5.5E+04
Nb-94			1.4E-07	8.4E-06	8.1E-07	2.6E-03	8.6E-07	5.9E-01	6.1E-07	5.9E-01
Tc-99			9.0E-02	6.7E+00	5.2E-01	8.2E-01	5.5E-01	2.8E-01	3.9E-01	9.4E+00
I-129			1.5E-04	1.8E-02	8.4E-04	1.3E-03	8.9E-04		6.3E-04	2.2E-02
Cs-137			5.4E+02	4.6E+04	3.5E+03	4.2E+03	2.8E+03		2.0E+03	5.9E+04
Eu-152			5.8E-02	2.5E-01	3.2E-01	2.9E-01	2.0E-01		1.4E-01	1.3E+00
Eu-154			1.1E+01	4.0E+01	8.1E+01	5.4E+01	3.6E+01		2.6E+01	2.5E+02
Pb-210			7.9E-13	3.2E-10	9.1E-09	1.9E-09	7.2E-09		5.2E-09	2.4E-08
Ra-226			9.2E-12	8.0E-09	9.8E-07	4.7E-08	1.0E-06		1.0E-01	1.0E-01
Ra-228			3.8E-13	5.2E-14	9.9E-10	3.1E-13	1.5E-10		1.1E-10	1.3E-09
Ac-227			1.0E-07	4.6E-08	3.3E-07	2.7E-07	2.7E-07		1.9E-07	1.2E-06
Th-228			3.9E-06	3.6E-05	6.0E-02	2.1E-04	4.8E-02		3.4E-02	1.4E-01
Th-229			3.2E-11	9.9E-10	2.8E-09	5.8E-09	2.2E-09		1.6E-09	1.3E-08
Th-230			5.0E-09	9.4E-06	4.8E-06	5.5E-05	3.8E-06		2.7E-06	7.6E-05
Th-232		1.1E-02	1.3E-12	3.1E-13	9.1E-12	1.8E-12	7.2E-12		5.1E-12	2.5E-11
Pa-231			8.9E-07	7.5E-07	8.8E-07	4.4E-06	7.0E-07		5.0E-07	8.1E-06
U-232			2.3E-08	5.0E-05	9.6E-05	2.9E-04	9.6E-05		6.9E-05	6.0E-04
U-233			2.4E-10	1.9E-06	1.3E-07	1.1E-05	1.4E-07		9.8E-08	1.3E-05
U-234	6.6E-02	4.3E-01	3.1E-03	2.7E-01	9.2E-03	1.6E+00	9.7E-03		6.9E-03	1.9E+00
U-235	2.3E-03	1.7E-02	2.2E-05	9.0E-03	6.0E-05	5.3E-02	6.3E-05		4.5E-05	6.2E-02
U-236			5.7E-05	1.8E-03	1.5E-04	1.0E-02	1.6E-04		1.1E-04	1.2E-02
U-238	9.9E-02	2.3E-01	1.1E-06	1.3E-03	3.1E-06	7.5E-03	3.3E-06		2.3E-06	8.8E-03
Np-237			1.1E-04	1.3E-04	9.0E-04	7.8E-04	9.5E-04		6.8E-04	3.6E-03
Pu-238			5.5E+00	1.7E-02	1.2E+01	1.0E-01	1.2E+01		8.3E+00	3.8E+01

Table 15. (continued).

Nuclide	Acid Pit (Ci)	Solid Actinides (Ci)	Navy Disposals (Ci)	Vycor Glass (Ci)	Calcine (Ci)	Sludge (Ci)	Tank Farm Soil (Ci)	Irradiated Hardware (Ci)	General Plant Waste (Ci)	Total
Pu-239		1.9E-01	7.0E-02	7.1E-01	1.8E-01	4.2E+00	1.9E-01		1.4E-01	5.5E+00
Pu-240			6.4E-02	5.3E-03	1.4E-01	3.1E-02	1.5E-01		1.1E-01	5.0E-01
Pu-241			7.7E+00	3.2E-03	2.6E+01	1.9E-02	1.7E+01		1.2E+01	6.3E+01
Pu-242			1.4E-04	1.3E-10	2.9E-04	7.8E-10	3.1E-04		2.2E-04	9.6E-04
Pu-244			2.5E-17	1.6E-21	4.4E-12	9.1E-21	4.7E-12		3.3E-12	1.2E-11
Am-241			3.2E-01	1.8E-05	7.6E-01	1.0E-04	8.2E-01		5.9E-01	2.5E+00
Am-243			8.4E-09	5.5E-12	1.9E-03	3.2E-11	7.8E-03		5.5E-03	1.5E-02
Cm-243			4.1E-09	1.3E-11	3.1E-04	7.6E-11	2.5E-04		1.8E-04	7.4E-04
Cm-244			5.4E-08	2.8E-12	1.9E-02	1.6E-11	1.5E-02		1.1E-02	4.5E-02
Cm-245			7.0E-13	6.8E-18	1.7E-06	4.0E-17	1.4E-06		9.8E-07	4.1E-06
Cm-246			1.1E-14	4.0E-21	1.4E-07	2.4E-20	1.1E-07		7.7E-08	3.3E-07
Cm-247			2.6E-21		1.8E-13	0.0E+00	1.4E-13		1.0E-13	4.2E-13
Cm-248			5.1E-22		2.1E-13	0.0E+00	1.7E-13		1.2E-13	5.0E-13
									Total	2.8E+05

From the above list, an overall maximum uncertainty was assigned to each waste type in Table 16 to generate activities. Best-estimate contaminant activities were baseline activities. Baseline estimates were a composite of either gross reported nuclides or nuclides inferred from baseline numbers using appropriate scaling factors.

Table 16. Uncertainty multipliers.

	General Waste	High Uncertainty	Sludge	Soil	Calcine/ Filters
Lower Bound	0.66	0.5	0.2	0.2	0.33
Best Estimate	1	1	1	1	1
Upper Bound	1.5	2	3	3	3

Because of the highly variable and shipment-dependent nature of many of the waste streams, standard statistical uncertainty methods were not feasible. As in the original comprehensive reports (LMITCO 1995a, 1995b), the methodology for defining the above best-estimate activities and associated upper and lower bounds was not based on a rigorous statistical error propagation model but rather as approximation methods based on professional judgment and reasonable assumptions. A similar approach is applied for this assessment (also see Section 4.5). The upper bound values in Table 16 represent the error factors that are multiplied to produce an upper bound and divided to produce a lower bound. This method presents a proportional uncertainty rather than a balanced uncertainty that is possible with measured results. With large uncertainties that are judgment-based, this is the best representation of uncertainty.

4. ESTIMATED RADIOLOGICAL INVENTORY FOR 1984 THROUGH 1993

4.1 Background

This section discusses the reassessment of waste sent from INTEC to the SDA for disposal during the RPDT period from 1984 through 1993. The three main radiological contaminant categories associated with this period were fission products, trace activation products, and trace actinide contaminants. Trace activation products were reported for only a small fraction of the total reported shipments.

From 1984 through 1993, operations at INTEC included receiving expended fuel for storage, fuel reprocessing, and the processing of liquid raffinates into calcine. In 1992, fuel reprocessing was discontinued, but calcining operations continued through 1999.

During this later period, disposals in the SDA of all contaminants were small in relation to disposals during the earlier period. Most disposals were significantly less than one curie of activity. Additionally, all known disposals consisted of low-level, contact-handled waste. This contrasts with the period 1952 through 1983, during which significant amounts of remote-handled waste, such as irradiated subassembly hardware and WCF filters, were buried in either soil vaults or trenches (see Section 3). The absence of remote-handled disposals during the 1984 through 1993 period was connected to more conservative waste disposal practices and changing missions at INTEC. From 1984 through 1993, yearly activity disposals to the SDA showed variable trends ranging from 7.2E-02 to 3.0E+02 Ci with net disposals amounting to 1.4E+03 Ci. Disposal practices from 1984 through 1993 were relatively uniform until about 1990 when net activities significantly declined. These disposal trends are quantified in Table 17. Table 17 presents yearly inventory disposals of net radionuclide activities. Part of the decline seen in Table 17 was attributed to ceasing fuel reprocessing in 1992 at INTEC.

Table 17. Summary of net yearly activities of INTEC waste buried at SDA from 1984 through 1993.

Year	Activity (Ci)
1984	3.0E+02
1985	1.1E+02
1986	2.1E+02
1987	2.2E+02
1988	1.9E+02
1989	9.5E+01
1990	2.1E+02
1991	2.4E+01
1992	2.1E+00
1993	7.2E-02
Totals	1.4E+03

4.2 Disposal Waste Streams

The original (LMITCO 1995a) and modified waste streams for 1984 through 1993 are in Table 18. Generally, the reassessment of data for this period indicated that original waste streams included in Table 2 were reasonably complete. However, to develop updated isotopic profiles more efficiently, waste stream descriptions were redefined using methods similar to those presented in Section 3.13 for the HDT period.

All shipments of GPW containing contaminants from fission products were reclassified and combined into waste stream INTEC-MOD-1R. Although actinides were not explicitly identified as contaminants in this waste stream, trace contamination existed. These contact-handled shipments of GPW resulted from routine plant operations, including decontamination activities, repairs, and equipment replacement and removal. This stream includes most of the low-level waste shipments listed in the original waste streams CPP-601-8R through CPP-684-1R in Table 18.

All known filter waste was reclassified as INTEC-MOD-2R. These particular LLW streams appeared to have higher concentrations of contaminants relative to most of the GPW streams and were therefore broken out separately. The majority of the identified filter waste came from the atmospheric protection system (APS). In addition to reported fission product contamination, there were also trace amounts of actinides in these filter disposals (see Section 3.8 on calcine filter waste disposals). Filter waste disposals showed intermittent patterns and were not explicitly reported for every year from 1984 through 1993. Known disposals of filters to the SDA ended after 1988.

Similarly, explicitly identified hot cell waste (sometimes referred to as “dry active waste”) was a separately identified waste stream because it had higher contaminant concentrations relative to most GPW disposals. Hot cell waste was identified as INTEC-MOD-3R. Most known disposals came from CPP-610. This stream contained fission products, but there was no estimate of accompanying actinides. It was concluded that this stream also had to contain trace actinide contaminants since these streams were related to operations that handled fuel or dissolved fuel products. Known disposals of explicitly identified hot cell waste to the SDA ended after 1988.

The hot cell and filter waste was derived from a variety of buildings with the remainder relegated to GPW. Going from building-designated waste streams to waste-type waste streams eliminates any correlation between the original and modified streams.

4.3 Data Collection and Analysis

Data collection for the RPDT period relied mainly on RWMIS disposal information that had been reformatted and entered into EXCEL spreadsheets, which are chronologically ordered for each year from 1984 through 1993. This disposal information was entered on individual shipment records, each entry record containing date and location of the disposal, the general contents (using a numerical waste stream identification code) and shipping container (using a numerical container identification code). With these entries were estimates of the net activities and isotope specific activities. However, the reported nuclides were generally limited to activities for Cs-137, Sr-90, and occasionally a few other short half-lived contaminants, such as Eu-154 or Eu-152. A summary of net reported contaminant activities is in Table 19. A detailed yearly listing of these disposals is in Appendix B. Methods to estimate contaminant inventories that are more comprehensive are discussed in the next section.

Table 18. Original and modified descriptions for INTEC waste streams buried in the SDA from 1984 through 1993.[a]

Original Waste Stream Descriptions[b]		Modified Waste Stream Descriptions	
Waste Stream Number	Description of Waste	Waste Stream Number	Description of Waste
CPP-601-8R	Waste from the fuel reprocessing building resulting from replacement and/or removal of equipment, asbestos, and materials used for decontamination of the facility	INTEC-MOD-1R	GPW consisting of both compactable and noncompactable material. Compactable material included material such as cloth, paper, plastic. Noncompactable material consisted of miscellaneous concrete, metal, building materials, fuel charging casks, lead, and asbestos. Main contaminants were fission and trace actinides.
CPP-604-2R	Pieces of equipment, insulated piping, contaminated soil, asbestos, and cleaning material such as cloth, paper, plastic, etc	INTEC-MOD-2R	HEPA filters (other than NWCF) from various buildings such as the APS that contain mixed fission products and traces of actinide contaminants.
CPP-605-1R	HEPA filters, metal, soil, concrete, and cleanup materials such as paper and cloth from the facility that contains the off-gas cleanup system	INTEC-MOD-3R	Hot cell waste that contained fission, trace activation, and actinide products from such buildings as CPP-610.
CPP-610-1R	Building materials, equipment, cleanup materials, metals, filters, fuel storage racks, and lead sheets and bricks from various areas		
CPP-649-1R	Filters from the APS, and construction materials from upgrading of the facility		
CPP-659-1R	Metals, construction materials, and cleanup materials such as paper, cloth, plastic, and concrete from the NWCF		
CPP-666-1R	Waste from 16 buildings, mostly construction materials, fuel charging casks, cleanup materials, and liquids solidified in Portland cement		
CPP-684-1R	Waste from the Remote Analytical Facility, construction materials and cleanup materials		

a. Note that the original waste stream descriptions were based on the building the waste came from. Modified descriptions are based on waste type; therefore, there is not a direct correspondence between old and new.
b. Original waste streams defined as part of the Historical Data Task (LMITCO 1995a).
APS= Atmospheric Protection System
HEPA = high-efficiency particulate air
NWCF= New Waste Calcine Facility

Table 19. Net disposals of fission products and actinide contaminant inventories in SDA pits from 1984 through 1993 documented in RWMIS.

Nuclide	RWMIS pit disposals from 1984 through 1993 (Ci)
Co-60	1.9E-01
Sr-90	1.0E+02
Cs-137	1.5E+02
Eu-152	6.5E+00
Eu-154	4.6E+00
Mixed Fission Products	1.4E+02

4.4 Estimated Contaminant Inventories

The baseline activities for Cs-137 reported in Table 19 were used as a frame of reference to estimate other unreported contaminants of interest. For 1984 through 1993, Cs-137 was chosen as the baseline reference isotope because it was a consistently reported gamma emitter. Cesium-137 activities were logged in most RWMIS shipments. Logged Cs-137 activities constituted a significant fraction of the total reported MFP gamma activities. Net Cs-137 gamma activities were then scaled to calculate other nuclides of interest—such as I-129—that were not explicitly reported for 1984 through 1993.

The scaling factors used to update nuclide profiles during the 1984 through 1993 period were based on the same generic calcine-based WCF scaling factors used in section 3.8 of this document. The justification for using these similar scaling factors is twofold. First, the source of the contamination is similar to latter periods of the HDT (projects such as fuel reprocessing, operations at the NWCF, and others, generated similar kinds of waste) (see Section 3). Second, the generic scaling factors have a documented analytical trail. The amount of effort required to research and calculate refined scaling factors, using ORIGEN and documentation of plant activities during this time frame, would not justify any differences that might be found in the relatively small amount of radiological activity in these waste streams. For similar reasons—although disposals for the RPDT are broken down into three separate waste streams (Table18)—the same set of calcine generic scaling factors will be applied to each stream to calculate a net total in this section.

The best-estimate inventories for fission products and actinide waste streams sent to the SDA from INTEC from 1984 through 1993 are presented in Table 20. Upper and lower bounds are also presented in Table 20. These estimates were based on scaling to the total recorded Cs-137 activity to calcine scaling factors as explained in Appendix E. The net Cs-137 activity was set equal to the reported cesium activity (in TableE-4) plus an assumed equivalent Cs-137 activity. This added Cs-137 activity was conservatively set equal to 0.25 the total reported MFP activity in Table 19. The lower-bound activities in Table 20 were estimated by multiplying the net equivalent Cs-137 activity by the scaling factors in Appendix B. A detailed annual breakdown of these disposals is found in Appendix F, Section F-11.

Table 20. Best estimates of net radionuclide contaminants sent from INTEC to the SDA from 1984 through 1993.

Nuclide	Lower Bound (Ci)	Best Estimate (Ci)	Upper Bound (Ci)
H-3	3.47E-01	5.2E-01	7.80E-01
Co-60	1.53E-01	2.3E-01	3.45E-01
Ni-63	2.73E-02	4.1E-02	6.15E-02
Sr-90	1.20E+02	1.8E+02	2.70E+02
Tc-99	2.40E-02	3.6E-02	5.40E-02
I-129	3.87E-05	5.8E-05	8.70E-05
Cs-137	1.20E+02	1.8E+02	2.70E+02
Eu-152	8.67E-03	1.3E-02	1.95E-02
Eu-154	1.60E+00	2.4E+00	3.60E+00
U-234	4.27E-04	6.4E-04	9.60E-04
U-235	2.80E-06	4.2E-06	6.30E-06
U-236	6.67E-06	1.0E-05	1.50E-05
U-238	1.47E-07	2.2E-07	3.30E-07
Np-237	4.13E-05	6.2E-05	9.30E-05
Pu-238	5.07E-01	7.6E-01	1.14E+00
Pu-239	8.00E-03	1.2E-02	1.80E-02
Pu-240	6.47E-03	9.7E-03	1.46E-02
Pu-241	7.33E-01	1.1E+00	1.65E+00
Am-241	3.60E-02	5.4E-02	8.10E-02
Am-243	3.40E-04	5.1E-04	7.65E-04

4.5 Uncertainties

The contaminant uncertainties for the 1984 through 1993 period parallel those for the 1952 through 1983 period. Documentation limitations—as well as other factors needed to make estimates with reasonable uncertainties—affected estimates of contaminant disposals for waste streams containing activation products, fission products, and actinide products.[v] The major contributors to such uncertainties are:

- Uncertainties in reporting and measurements quantifying isotopic activities of shipments

v. One of the major uncertainties associated with interpreting shipping records for the RPDT period is correlating a waste stream process with specific shipment entries. The corresponding shipping manifest often identified the building and container numbers from the origin of the disposals, but did not describe the irradiation history connected with the attendant waste from fission products.

- Uncertainties in ORIGEN-based scaling factor results (e.g., uncertainties in cross-sections and decay times)

- Uncertainties from nonuniform isotopic profiles in the reported waste streams.

The basis for determining uncertainty was previously discussed in Section 3.14.

Best-estimate contaminant activities are baseline activities. Baseline estimates are a composite of either gross reported nuclides or nuclides inferred from baseline numbers using appropriate scaling factors. The consistency of reporting in the RPDT results in a uniform uncertainty estimate of a factor of 1.5.

5. CONCLUSIONS AND RECOMMENDATIONS

This report documents the reassessment of the activity in INTEC waste that was buried at the SDA from 1952 through 1993. These waste streams consisted of fission products, activation products, and actinide contaminants, all of which were reassessed in this report. Generally, documentation for shipments after 1983 was more complete than earlier shipments. Activity estimates for activation, fission, and actinide contaminants for 1952 through 1993 are in Table 21. The activities shown in Table 21 are the sum of inventories for the two periods previously discussed in Sections 3 and 4. From Table 21, it is clear that the contaminant disposals during the HDT period were significantly larger relative to the RPDT disposals (Section 4). This contrast is due to tighter restrictions during the later (RPDT) period on types of waste that could be sent to the SDA. For instance, during the RPDT period, no remote-handled disposals were sent to the SDA; only LLW was buried at the SDA during that time.

Ninety-eight percent of the 2.8E+05 total curies contained in the waste are represented by only three isotopes. Co-60 from EBR-II activated hardware represents 57% of the total. Sr-90 and Cs-137 from the Vycor glass disposals represent 20% and 21% respectively. Transuranic isotopes amount to only about 100 Ci.

Original HDT and RPDT waste streams did not include all radiological contaminants of concern identified in the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002). Previously unreported contaminants were estimated here using recent ORIGEN2 analysis of specific waste streams. Isotopic activities in HDT and RPDT waste streams determined to be excessively over- or underestimated were revised. In the case of the one-time-only Navy disposals of 1969, longer-lived contaminants like Cs-137 were over-estimated by several orders of magnitude. In the case of contaminated sludge disposals, net actinide contaminants were under-estimated and were not consistent with reported actinide assays of the sludge from the storage basins at CPP-603. For irradiated hardware, previously reported activities for Nb-94, Ni-63, and C-14 were unrealistically large. The revised estimates for these waste streams are compared to original HDT and RPDT estimates in Table 21.

The best-estimate analysis of activation-product disposals associated mainly with irradiated subassembly hardware was judged as isotopically accurate for two reasons:

- Documentation of soil vault disposals of activated products showed that all of the associated shipping records and supporting documentation had been located by personnel from ANL-W and INEEL

- Extensive calculations (using ORIGEN2), using known irradiation histories for the EBR-II hardware components, produced realistic estimates of the activation product inventory in this waste stream.

Similarly, reassessed contaminant profiles for the WCF filter disposals were also judged as accurate. The reasons for this conclusion are two-fold:

- Again, extensive investigations accounted for all WCF disposals.

- Descriptions of year-to-year disposals and descriptions of the kind of raffinates reprocessed along with other operational data were located.

As for irradiated hardware, computational analysis using the ORIGEN2 computer code was extensive. It was judged that averaged scaling factors from the WCF analysis were applicable to such minor fission product-bearing waste streams such as GPW.

Table 21. Reassessed best-estimate activities sent to the SDA from INTEC from 1952 through 1993.

Nuclide	Best-Estimate Disposals from 1952 through 1983 (Ci)	Best-Estimate Disposals from 1984 through 1993 (Ci)	Total Best-Estimate Disposals from 1952 through 1993 (Ci)	Total HDT/RPDT Best-Estimate Report[a] (Ci)
H-3	3.8E+02	5.2E-01	3.8E+02	—
Be-10	1.9E-06	6.9E-09	2.0E-06	—
C-14	2.6E+00	2.9E-07	2.6E+00	4.3E+01
Cl-36	1.4E-03	0.0E+00	1.4E-03	—
Co-60	1.6E+05	2.3E-01	1.6E+05	2.0E+05
Ni-59	1.1E+01	6.1E-04	1.1E+01	1.6E+02
Ni-63	8.5E+02	4.1E-02	8.5E+02	2.5E+04
Sr-90	5.5E+04	1.8E+02	**5.8E+04**	2.0E+04
Nb-94	5.9E-01	5.6E-08	5.9E-01	4.7E+01
Tc-99	9.4E+00	3.6E-02	**9.7E+00**	3.0E-02
I-129	2.2E-02	5.8E-05	2.3E-02	—
Cs-137	5.9E+04	1.8E+02	**6.1E+04**	4.2E+04
Eu-152	1.3E+00	1.3E-02	1.4E+00	2.4E+02
Eu-154	2.5E+02	2.4E+00	2.8E+02	2.9E+02
Pb-210	2.4E-08	4.7E-10	2.9E-08	—
Ra-226	1.0E-01	6.7E-08	3.6E-06	—
Ra-228	1.3E-09	1.0E-11	1.4E-09	—
Ac-227	1.2E-06	1.7E-08	1.4E-06	—
Th-228	1.4E-01	3.1E-03	1.8E-01	—
Th-229	1.3E-08	1.4E-10	1.5E-08	—
Th-230	7.6E-05	2.5E-07	7.9E-05	—
Th-232	2.5E-11	4.7E-13	1.1E-02	—
Pa-231	8.1E-06	4.6E-08	8.7E-06	—
U-232	6.0E-04	6.3E-06	6.8E-04	—
U-233	1.3E-05	9.0E-09	1.3E-05	—
U-234	1.9E+00	6.4E-04	2.4E+00	4.8E+01
U-235	6.2E-02	4.2E-06	8.1E-02	1.6E-01
U-236	1.2E-02	1.0E-05	1.3E-02	4.0E-03
U-238	8.8E-03	2.2E-07	3.4E-01	6.6E-01
Np-237	3.6E-03	6.2E-05	4.3E-03	—
Pu-238	3.8E+01	7.6E-01	4.6E+01	1.0E+01
Pu-239	5.5E+00	1.2E-02	5.8E+00	4.8E-01
Pu-240	5.0E-01	9.7E-03	6.1E-01	1.0E-02
Pu-241	6.3E+01	1.1E+00	7.5E+01	1.5E+01
Pu-242	9.6E-04	2.0E-05	1.2E-03	1.0E-01

Table 21. (continued).

Nuclide	Best-Estimate Disposals from 1952 through 1983 (Ci)	Best-Estimate Disposals from 1984 through 1993 (Ci)	Total Best-Estimate Disposals from 1952 through 1993 (Ci)	Total HDT/RPDT Best-Estimate Report[a] (Ci)
Pu-244	1.2E-11	3.1E-13	1.6E-11	—
Am-241	2.5E+00	5.4E-02	3.1E+00	—
Am-243	1.5E-02	5.1E-04	2.1E-02	—
Cm-243	7.4E-04	1.6E-05	9.2E-04	—
Cm-244	4.5E-02	9.9E-04	5.7E-02	—
Cm-245	4.1E-06	9.0E-08	5.1E-06	—
Cm-246	3.3E-07	7.1E-09	4.1E-07	—
Cm-247	4.2E-13	9.2E-15	5.3E-13	—
Cm-248	5.0E-13	1.1E-14	6.4E-13	—
Totals	2.8E+05	3.7E+02	2.8E+05	2.9E+05

a. LMITCO (1995a, 1995b).

Bold indicates best-estimates that are greater than original HDT/RPDT estimates.

In contrast, best estimates of fission products and actinide waste contaminants for several other major fission-products-bearing waste streams are not as well documented. These include basin sludge from CPP-603, contaminated soil from the Tank Farm, and Vycor glass. More conservative assumptions were made in estimating activities in these waste streams.

Definitions of lower bound, best estimate, and upper bound were not generally grounded in standard statistical methods. The methodology for defining the above best-estimate activities and associated upper and lower bounds was based on professional judgment and reasonable assumptions. Bounding uncertainty analysis was waste stream-specific and had significant variations. The rationale for not using rigorous statistical methods was the consequence of highly variable waste disposals that made such methods unfeasible or impractical.

6. REFERENCES

42 USC § 9601 et seq., 1980, "Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA/Superfund)," *United States Code.*

AEC Form 110, 1964, "Waste Disposal Request and Authorization," U.S. Atomic Energy Commission Idaho Operations Office, Idaho Falls, Idaho, November 1964.

Berreth, J. R., 1988, "Inventories and Properties of ICPP Calcined High-Level Waste," WINCO 1050, UC70.

Bjorklund, W. J., G. F. Offutt, and R. D. Denney, 1974, *First Electrolytic Dissolution Campaign of EBR-II Fuel at ICPP*, IC-10.

Carboneau, M. L., INEEL, letter to J. A. Logan, INEEL, February 27, 1998, "Reassessment of Neutron-Activation-Product Curies Sent from EBR-II to Disposal at the RWMC," MLC-01-98.

Croff, A. G., 1980, *ORIGEN2—A Revised and Updated Version of the Oak Ridge Isotope Generation and Depletion Code*, ORNL-5621, Oak Ridge National Laboratory.

DOE-ID, 2000, *Operable Unit 3-14 Tank Farm Soil and Groundwater Phase I Remedial Investigation/Feasibility Study Work Plan*, DOE/ID-10676, Rev. 0, U.S. Department of Energy Idaho Operations Office.

EG&G, 1985, *A History of the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory,* WM-F1-81-003, Rev. 3, Idaho National Engineering and Environmental Laboratory.

Houston, S., E. D. Jonas, and K. M. Wendt (Editor), 1991, *A Review of Fuel Processing Campaign 37 Fourth Electrolytic Dissolution of EBR-II Fuel at the Idaho Chemical Processing Plant*, WIN-246.

Holdren, K. Jean and Barbara J. Broomfield, 2003, *Second Revision to the Scope of Work for the Operable Unit 7-13/14 Waste Area Group 7 Comprehensive Remedial Investigation/Feasibility Study*, INEL-95/0253, Rev. 2, Idaho National Engineering and Environmental Laboratory.

Holdren, K. Jean, Bruce H. Becker, Nancy L. Hampton, L. Don Koeppen, Swen O. Magnuson, T. J. Meyer, Gail L. Olson, and A. Jeffrey Sondrup, 2002, *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area,* INEEL/EXT-02-01125, Rev. 0, Idaho National Engineering and Environmental Laboratory.

Jorgensen, D. K., D. J. Kuhns, J. J. King, and C. A. Loehr, 1994, *WAG 7 Operable Unit (OU) 7-02 Acid Pit Track 2 Summary Report*, EGG-ERD-10242.

Lewis, L. C., D. C. Barg, C. L. Bendixsen, J. P. Henscheid, D. R. Wenzel, and B. L. Denning, 2000, *Idaho National Engineering and Environmental Laboratory Site Report on the Production and Use of Recycled Uranium*, INEEL/EXT-2000-00959.

LMITCO, 1995a, *A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1952–1983*, INEL-95/0310, Rev. 1, Idaho National Engineering and Environmental Laboratory.

LMITCO, 1995b, *A Comprehensive inventory of Radiological and Nonradiological Contaminants in Waste Buried or Projected to be Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1984–2003,* INEL-95/0135, Rev. 1, Idaho National Engineering and Environmental Laboratory.

Mortimer, S. R., 1978, "Second Electrolytic Dissolution Campaign of EBR-II Fuel at ICPP," ICP-1168.

Mortimer, S. R., 1981, "Third Electrolytic Dissolution Campaign of EBR-II Fuel at ICPP," ENICO-1078.

Osloond, J. H., 1970, *Waste Disposal Data for the National Reactor Testing Station Idaho*, IDO-12074.

Palmer, W. B., C. B. Millet, M. D. Staiger, and F. S. Ward, 1998, *ICPP Tank Farm Planning Through 2010*, INEEL/EXT-98-00339.

Plansky, L. E. and S. A. Hoiland, 1992, *Analysis of the Low-Level Waste Radionuclide Inventory for the Radioactive Waste Management Complex Performance Assessment*, EGG-WM-9857, Rev. 1.

Smith, R. R., 1974, *Final Safety Analysis for ICPP-603 Fuel Storage Basin Cleanup Systems,* ACI-132.

Staiger, M. D., 1999, *Calcine Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455.

Stevenson, C. E., 1987, *The EBR-II Fuel Cycle Story*, LaGrange Park, Illinois: American Nuclear Society.

Wenzel, D. R., 2000a, "Determination of the Normalized Mass of Individual Radionuclides in the Dissolver Product for Aluminum, Zirconium and Stainless Steel Fuel Previously Processed at INTEC," EDF INTEC-2000-006.

Wenzel, D. R., 2000b, "Assessment of the Radionuclide Activities in WCF Filters Shipped to the RWMC Between 1964 and 1981," EDF INTEC-2000-001/1642.

WINCO, 1993, *Track 2 Summary Report for Operable Unit 3-07 (Tank Farm Area I)*, Westinghouse Idaho Nuclear Company, Inc., Rev. 2.